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JSC-09434

NASA CR-

144355

PROGRAM DOCUMENTATION

SURFACE HEATING RATE OF THIN SKIN MODELS (THNSKN)

Program Q614

Job Order 83-157

(This revision supersedes 07000 dated November 1969)

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SURFACE HEATING RATE OF THIN SKIN MODELS
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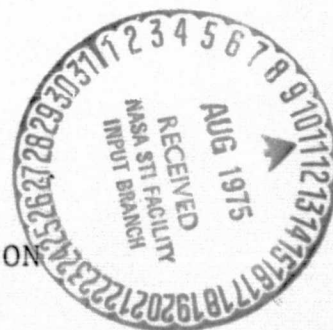
Prepared By

Lockheed Electronics Company, Inc.
Aerospace Systems Division
Houston, Texas

Contract NAS 9-12200

For

INSTITUTIONAL DATA SYSTEMS DIVISION



National Aeronautics and Space Administration
LYNDON B. JOHNSON SPACE CENTER

Houston, Texas

April 1975

LEC-5523

PROGRAM DOCUMENTATION
SURFACE HEATING RATE OF THIN SKIN MODELS (THNSKN)

Program Q614

Job Order 83-157

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LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS

April 1975

TECHNICAL REPORT INDEX/ABSTRACT
(See instructions on reverse side.)

1. TITLE AND SUBTITLE OF DOCUMENT Program Documentation Surface Heating Rate of Thin Skin Models (THNSKN)		2. JSC NO. JSC-09434									
3. CONTRACTOR/ORGANIZATION NAME Lockheed Electronics Company, Inc.	4. CONTRACT OR GRANT NO. NAS 9-12200										
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13. ABSTRACT THNSKN computes the mean heating rate at a maximum of 100 locations on the surface of thin skin transient heating rate models. Output is printed in tabular form and consists of time history tabulation of temperatures, average temperatures, heat loss without conduction correction, mean heating rate, least squares heating rate, and the percent standard error of the least squares heating rates. The input tape used is produced by the program EHTS03.											
14. SUBJECT TERMS <table style="width:100%; border: none;"> <tr> <td style="border-bottom: 1px solid black; width: 33%;">ARC JET</td> <td style="border-bottom: 1px solid black; width: 33%;">THERMOCOUPLES</td> <td style="border-bottom: 1px solid black; width: 33%;"></td> </tr> <tr> <td style="border-bottom: 1px solid black;">HEATING RATE</td> <td style="border-bottom: 1px solid black;"></td> <td style="border-bottom: 1px solid black;"></td> </tr> <tr> <td style="border-bottom: 1px solid black;">THIN SKIN</td> <td style="border-bottom: 1px solid black;"></td> <td style="border-bottom: 1px solid black;"></td> </tr> </table>			ARC JET	THERMOCOUPLES		HEATING RATE			THIN SKIN		
ARC JET	THERMOCOUPLES										
HEATING RATE											
THIN SKIN											

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LIST OF ATTACHMENTS

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1	Lead Card Setup
2	Deck Setup
3	Run Request Card
4	Flow Chart
5	Program Listing
6	Sample Input
7	Sample Output
8	Correspondence
9	Diagnostic Messages

UNIT I
PROGRAM ABSTRACT AND HISTORY OF USE

A. ABSTRACT

Program THNSKN computes the mean heating rate at a number of thermocouple locations on the surface of thin skin transient heating rate models. Experimental data, calibrated in engineering units, is obtained from ABEL tape output of the EHTS03 data reduction computer program. The program output consists of time history tabulations in an array by thermocouple locations for each time sample.

B. PROGRAM HISTORY

The original THNSKN program was written in 1969. The current version was written in December 1974 as requested by SCR83-15-30.

UNIT II
PROGRAM USERS INFORMATION

A. IDENTIFICATION

Title: Surface Heating Rate of Thin
Skin Models (THNSKN)
Author: Jack D. McBryde
Date: December 1974
Installation: JSC, Houston, Texas
Authorization: Contract NAS 9-12200
Source Language: FORTRAN V
Computer Configuration: UNIVAC 1108 or 1110, EXEC 8

B. DESCRIPTION OF PROGRAM REQUEST

See attachment 8.

C. USAGE

1. Input Requirements and Data Descriptions:

The THNSKN input tape is produced by the program EHTS03. It is a FORTRAN-written binary tape containing time in floating-point seconds followed by data in floating point for N channels. The number of channels (N) is fixed for a given tape ($N \leq 259$).

See attachment 6 for sample input.

2. Lead Card Setup:

See attachment 1.

3. Deck Setup:

See attachment 2.

4. Tape Assignments:

See attachment 3.

5. Restrictions:

The following list is a summary of the restrictions:

- The input tape must have the format specified in section C.1.
- The array of thermocouples must have no more than 50 rows or columns, and one row or column must contain at least three thermocouples.
- Each specified time slice must contain at least three input records.
- The maximum number of points for thermocouples, which may be used for least squares heat loss computations, is 50.

6. Diagnostic, Normal-Console, and Standard-Output Messages:

See attachment 9.

7. Labels, Save-Tapes, and Output Disposition:

There is printer output only.

8. Output Formats:

See attachment 7.

9. Nonstandard System Requirements:

There are none.

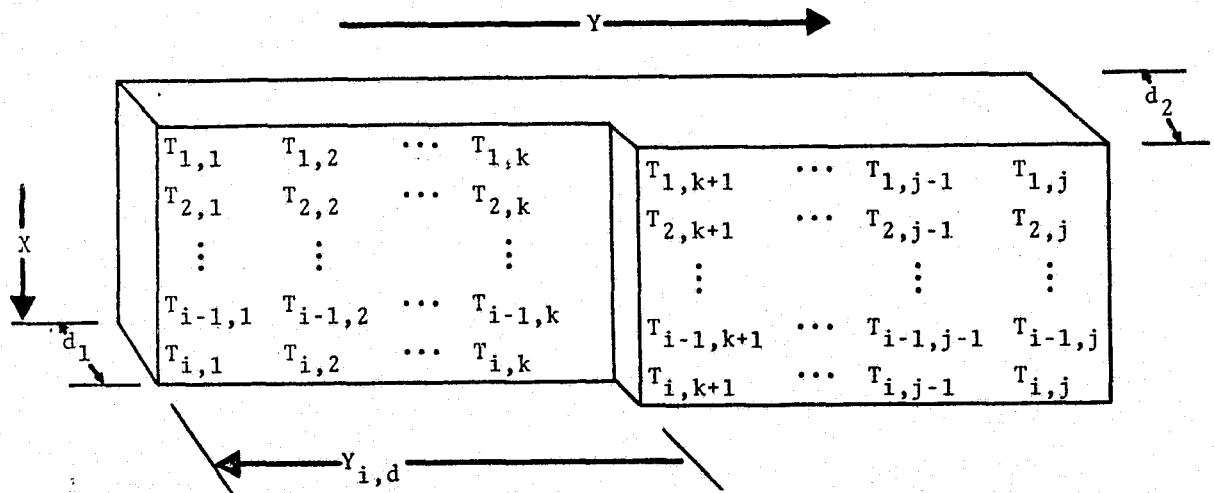
10. Running Time:

THNSKN processes nine thermocouples for 40 time points in less than 1/2 minute.

D. ANALYSIS

1. Description of the Relationship of Variables to the Test Item:

The test item may be considered to be a rectangular plate having, at most, two thicknesses as shown:



- The origin of the x -, y -coordinate system is the upper left corner.

- The variables d_1 and d_2 are the two thicknesses. If the test item has only one thickness, it is represented by d .
- The variable $T_{i,j}$ is the temperature at a thermocouple in degrees Fahrenheit.
- The variables $T_{i,k}$ and $T_{i,k+1}$ are temperatures adjacent to the thickness difference junction.
- The variable $Y_{i,d}$ is the y-coordinate of the junction at row i in inches.
- Each row or column is colinear in the X-, Y-plane so that the coordinates of all the thermocouples (X, Y) can be expressed using i-values of X and j-values of Y. Both X and Y are in inches.

2. Equations:

2.1 Mean temperatures:

The mean temperature \bar{T} for each thermocouple is computed by

$$\bar{T} = \frac{1}{N} \sum_{\ell=1}^N T_{\ell} \quad (1)$$

where N is the number of temperatures read in the time interval processed.

2.2 Mean heat flux without conduction correction:

The mean heat flux without conduction correction \bar{q} is computed by

$$\bar{q}_{i,j} = \frac{\rho C_p d}{24(t_N - t_1)} \frac{N-1}{N-2} \left(T_{i,j}^N + T_{i,j}^{N-1} - T_{i,j}^1 - T_{i,j}^2 \right) \quad (2)$$

where

t_1 = the time for the first scan of data in the interval in seconds.

t_N = the time for the last scan of data in the interval in seconds.

$T_{i,j}^1, T_{i,j}^2, T_{i,j}^{N-1}, T_{i,j}^N$ = the first, second, next to the last, and last temperatures of the thermocouple in row i and column j .

ρ = mass density in lb/ft^3 .

C_p = specific heat in $\text{BTU/lb}^\circ\text{F}$.

d = thickness of test material in inches.

If the test item has two thicknesses, then $d = d_1$, for $j \leq k$ (see the figure) and $d = d_2$ for $j > k$.

2.3 Mean lateral heat loss in the X-direction:

The mean lateral heat loss in the X-direction $\overline{q^x}$ is computed by

$$\overline{q_{i,j}^x} = \frac{24Kd}{X_{i+1} - X_{i-1}} \left(\frac{\overline{T}_{i,j} - \overline{T}_{i-1,j}}{X_i - X_{i-1}} - \frac{\overline{T}_{i+1,j} - \overline{T}_{i,j}}{X_{i+1} - X_i} \right) \quad (3)$$

where

K = thermal conductivity in BTU/ft sec°F.

d = d₁ for j ≤ k (see the figure).

d = d₂ for j > k .

2.4 Mean lateral heat loss in the Y-direction:

The mean lateral heat loss in the Y-direction $\overline{q^y}$ may be computed by one of three equations, depending on whether the test material has one or two thicknesses and the position of the thermocouple relative to the junction between the thicknesses.

Case 1: The variable $\overline{q^y}$ when the material has one thickness or where it has two and all three thermocouples are the same side of the junction.

$$\overline{q_{i,j}^y} = \frac{24Kd}{Y_{j+1} - Y_{j-1}} \left(\frac{\overline{T}_{i,j} - \overline{T}_{i,j-1}}{Y_j - Y_{j-1}} - \frac{\overline{T}_{i,j+1} - \overline{T}_{i,j}}{Y_{j+1} - Y_j} \right) \quad (4)$$

where

$$d = d_1 \quad \text{when } j + 1 \leq k .$$

$$d = d_2 \quad \text{when } j - 1 > k .$$

Case 2: The variable $\overline{q^y}$ when the material has two thicknesses and $j = k$ (see the figure).

$$\overline{q_{i,j}^y} = \frac{24Kd_1}{Y_{k+1} - Y_{k-1}}$$

$$\left(\frac{\overline{T}_{i,k} - \overline{T}_{i,k-1}}{Y_k - Y_{k-1}} - \frac{d_2(\overline{T}_{i,k+1} - \overline{T}_{i,k})}{(Y_d - Y_k)d_2 + (Y_{k+1} - Y_d)d_1} \right)$$

(5)

where

Y_d = the Y-coordinate of the function at row i
(see the figure).

Case 3: The variable $\overline{q^y}$ when the material has two thicknesses and $j = k + 1$.

$$\overline{q_{i,j}^y} = \frac{24Kd_2}{Y_{k+2} - Y_k}$$

$$\left(\frac{d_1(\overline{T}_{i,k+1} - \overline{T}_{i,k})}{(Y_d - Y_k)d_2 + (Y_{k+1} - Y_d)d_1} - \frac{\overline{T}_{i,k+2} - \overline{T}_{i,k+1}}{Y_{k+2} - Y_{k+1}} \right)$$

(6)

2.5 Mean heating rate:

The mean heating rate \bar{q} is computed from equations 2, 3, and 4, 5, or 6.

$$\bar{q}_{i,j} = \bar{q}_{i,j} + \overline{q_{i,j}^x} + \overline{q_{i,j}^y} \quad (7)$$

3. Special Treatment When the Array Contains Bad Thermocouples:

The variables \bar{q} , \bar{q}^x and \bar{q}^y are not computed for bad thermocouples. These values are set to zero.

In computing \bar{q}^x for a column containing one or more bad thermocouples, temperatures and x-coordinates of three successive good (but not necessarily adjacent) thermocouples are used.

The same procedure is used in computing \bar{q}^y .

4. The Variables \bar{q}^x and \bar{q}^y at Row or Column End Points:

The conduction correction (\bar{q}^x or \bar{q}^y) used at the end points (first or last good thermocouple) are the same as those computed for the adjacent thermocouple in the row or column.

5. Linear Least Squares Heating Rate and Percent Standard Error:

The heating rate at each thermocouple \bar{Q} is computed from the slope M by

$$\bar{\dot{Q}} = \frac{\rho C_p d}{12} M \quad (8)$$

The slope M is computed by

$$M = \frac{n \sum t_i T_i - \sum t_i \sum T_i}{n \sum t_i^2 - (\sum t_i)^2} \quad (9)$$

where

n = the number of scans.

t = time.

T = temperature.

The percent standard error E is computed by

$$E = \frac{S_n(M)}{M} \times 100 \quad (10)$$

$$S_n(M) = n \sigma_n(T) \left\{ (n - 2) \left[n \sum t_i^2 - (\sum t_i)^2 \right] \right\}^{1/2} \quad (11)$$

$$\sigma_n(T) = \frac{1}{n}$$

$$\left\{ n \sum T_i^2 - (\sum T_i)^2 - \frac{(n \sum t_i T_i - \sum t_i \sum T_i)^2}{n \sum t_i^2 - (\sum t_i)^2} \right\}^{1/2} \quad (12)$$

If the time slice specified contains more than n scans, the last time and corresponding temperatures are used as the first time and temperatures for the next n scans.

E. FLOW CHART

See attachment 4.

F. STORAGE REQUIREMENTS

Forty-three thousand decimal locations are required.

G. LIST OF SUBROUTINES

None.

H. LOCATION OF SOURCE AND BINARY DECKS

The Data Processing Systems Department of Lockheed Electronics Company, Inc., maintains all source and binary decks for this program.

I. PROGRAM LISTING

See attachment 5.

J. CORRESPONDENCE

See attachment 8.

ATTACHMENT 1

LEAD CARD SETUP

PRECEDING PAGE BLANK NOT FILMED

LEAD CARD SETUP

CARD NO. 1

JOB _____

NAME THNSKN

PAGE 1 OF 10

PROGRAMMER McBryde DATE 12/74

[illegible]

LEAD CARD SETUP

CARD NO. 2

JOB _____

PAGE 2 OF 10

NAME THNSKN

PROGRAMMER McBryde DATE 12/74

[illegible]

CONSTANTS

LEAD CARD SETUP

CARD NO. 3

JOB _____

PAGE 3 OF 10

NAME THNSKN

PROGRAMMER McBryde

DATE 12/74

FIELD ID	CARD COLUMNS	FORMAT	SYMBOLIC NAME	IDENTIFICATION
1	1-10	F10.3	RHO	Mass density (ρ) of test material in lbm/ft^3 .
2	11-20	F10.3	CP	Specific heat (C_p) of test material in BTU/lbm °F.
3	21-30	F10.3	BIGK	Thermal conductivity (K) of test material in BTU/ft sec °F.
4	31-40	F10.3	DD(1)	Test material thickness (d_1) in inches. If there is only one thickness in the sample, the next field will be left blank.
5	41-50	F10.3	DD(2)	The second test material thickness (D_2). If a second thickness is supplied, card 5 must appear in the deck.
6	51-53	I3	NX	Number* of x-coordinates: $1 \leq NV \leq 50$.
7	54-56	I3	NY	Number* of y-coordinates: $1 \leq NY \leq 50$.

Comment: *A minimum of a 1×3 or 3×1 array of x, y-coordinates is required.

MISCELLANEOUS RUN PARAMETERS

LEAD CARD SETUP

CARD NO. 4

JOB _____

PAGE 4 OF 10

NAME THNSKN

PROGRAMMER McBryde DATE 12/74

DATE 12/74

[illegible]

Comment: *The input tape record has a time word preceding the data channels. These numbers do not include the time word.

PAGE 5 OF 10

DATE 12/74

PROGRAMMER McBryde DATE 12/74

10

LEAD CARD SETUP

PROGRAMMER McBryde **DATE** 12/74

Comment: Enter as many cards as needed to define NX locations
(NX \leq 50).

LEAD CARD SETUP

PROGRAMMER McBryde DATE 12/74

[illegible]

Comment: Enter as many cards as required to define NY locations
(NY \leq 50).

THERMOCOUPLE CHANNEL NUMBERS

LEAD CARD SETUP

CARD NO. 8

JOB _____

PAGE 8 OF 10NAME THNSKNPROGRAMMER McBrydeDATE 12/74

FIELD ID	CARD COLUMNS	FORMAT	SYMBOLIC NAME	IDENTIFICATION
1	1-3	I3	IX	Row number (X-direction) of
				thermocouple.
2	4-6	I3	IY	Column number (Y-direction) of
				thermocouple.
3	7-10	I4	NTCH (IX,IY)	Channel number for temperature of
				thermocouple located at IX, IY.
4	11-13	I3	IX	} Second thermocouple.
5	14-16	I3	IY	
6	17-20	I4	NTCH (IX,IY)	
7	21-23	I3	IX	} Third thermocouple.
8	24-26	I3	IY	
9	27-30	I4	NTCH (IX,IY)	
10	31-33	I3	IX	} Fourth thermocouple.
11	34-36	I3	IY	
12	37-40	I4	NTCH (IX,IY)	
13	41-43	I3	IX	} Fifth thermocouple.
14	44-46	I3	IY	
15	47-50	I4	NTCH (IX,IY)	

Comment: Enter as many cards as needed to define NX * NY thermocouple locations. Bad thermocouples should be indicated with NTCH (IX,IY) = 0 .

START-STOP TIMES

LEAD CARD SETUP

CARD NO. 9

JOB _____

PAGE 9 OF 10

NAME THNSKN

PROGRAMMER McBryde DATE 12/74

FIELD ID	CARD COLUMNS	FORMAT	SYMBOLIC NAME	IDENTIFICATION
1	1-10	F10.3	TSTRT	Computation start time.
2	11-20	F10.3	TSTOP	Computation stop time.
3	21-30	F10.3	STATME	Start time for least squares curve fit.
				No data will be processed outside of
				the interval from TSTRT to TSTOP.
4	31-35	I5	NTME	The number of points to be curve fit.
				If $NTME \leq 2$, no curve fitting will
				be done.
				NOTE: This card will be used if IOPT1
				on card 4 is zero or blank. Card 9A
				will not be used and must not appear
				in the deck. As many start-stop time
				cards may be used as desired but the
				time slices must not overlap; i.e., the
				start time for the current time slice
				must be \geq the stop time for the
				previous time slice.

COMMAND EVENT START-STOP

LEAD CARD SETUP

CARD NO. 9A

JOB _____

PAGE 10 OF 10

NAME THNSKN

PROGRAMMER McBryde DATE 12/74

DATE 12/74

[illegible]

ATTACHMENT 2

DECK SETUP

(Back of deck)

7

8 PMD, E

One or more card 9A's if IOPT1
on card 4 is 1.One or more card 9's if IOPT1
on card 4 is 0.

CARDS 6 - 8

CARD 5 [Only if DD(2) on card 3 > 0]

THNSKN CARDS 1 - 4

7

8XQT .THNSKN/ABS

7

8MAP,S .THNSKN,THNSKN/ABS

7

8PREP

7

8COPIN PGMTP,TPF\$

7

8ASG,T 8,8C,XXXXXX (Input tape number)

7

8ASG,T PGMTP,8C,V02679

7

8MSG,N TWO TAPE DRIVES

7

8RUN

(Front of deck)

ATTACHMENT 3

RUN REQUEST FORM

INSTRUCTIONS FOR CENTRAL COMPUTER COMPLEX COMPUTER RUNS

RUNID

(DO NOT FILL IN SHADED AREAS)

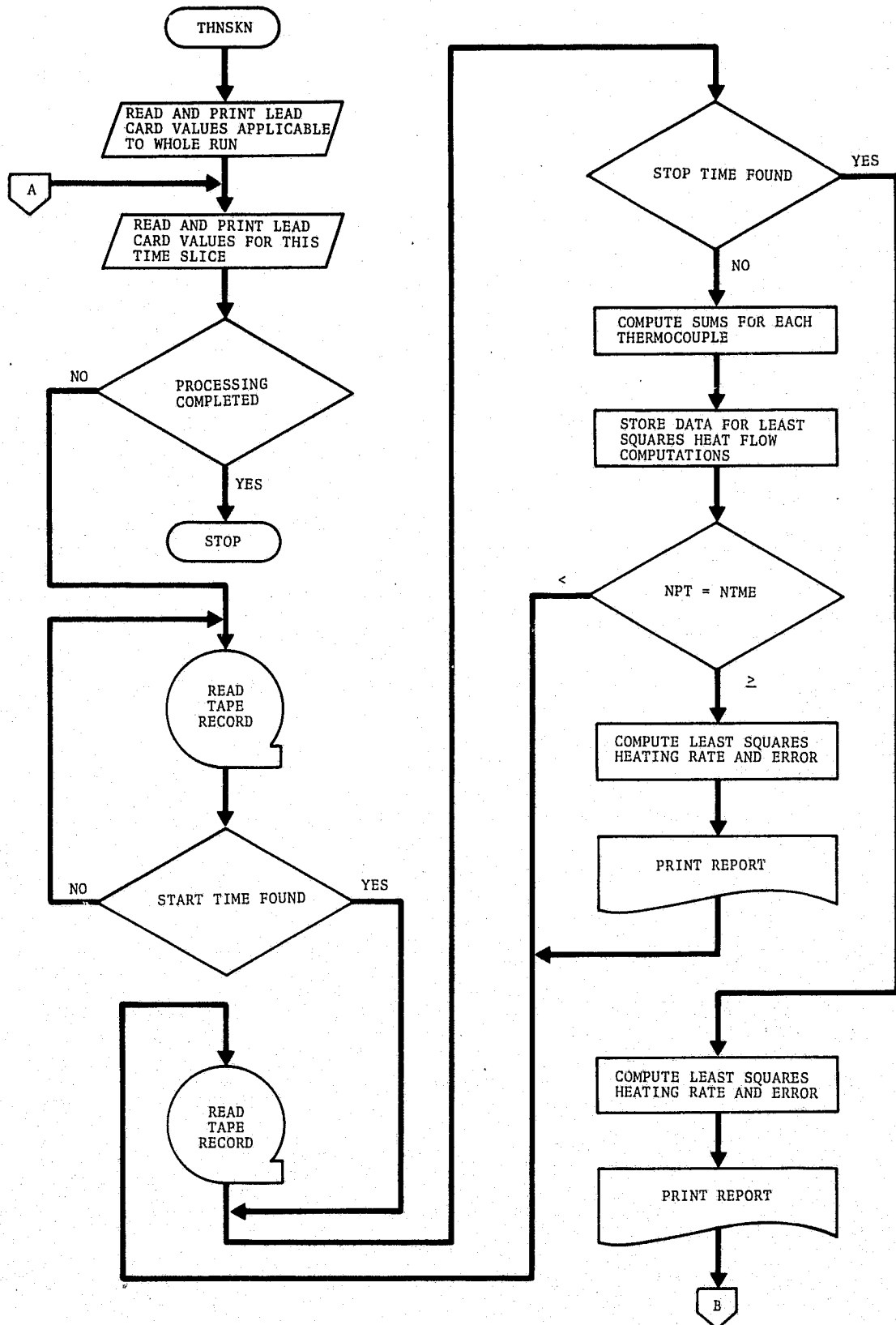
PROGRAMMER'S COMMENTS:

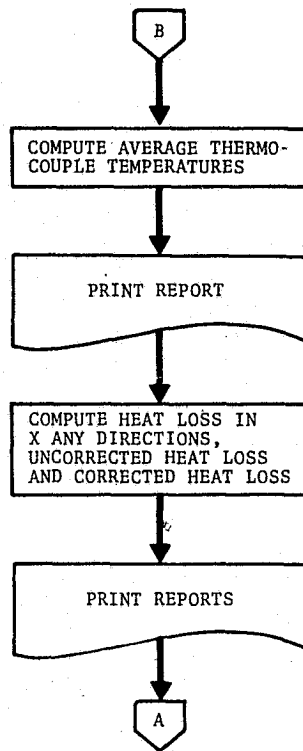
EXEC VIII

PROGRAMMER XXXXXX			BADGE NO. XXXX	BOX NO. XXX	PHONE NO. XXX	DATE XXX	PRIORITY & INITIALS	
DIVISION CODE FDXX	PROG. NO. Q614	PROJ. NO. XXXX	EST. TIME XX	MAX. TIME XX	PAGES OUTPUT XX	SEQ. NO.		
OPERATING SYSTEM				TYPE OF RUN		NO. TAPES	NO. FASTR FILES	NO. DRUM FILES
1108 EXEC II	<input type="checkbox"/>	3200 SCOPE	<input type="checkbox"/>	PROD	<input checked="" type="checkbox"/>	TEST	<input type="checkbox"/>	
1108 EXEC III	<input checked="" type="checkbox"/>	3200 SMARTS	<input type="checkbox"/>	OTHER (EXPLAIN BELOW)				
1108 COBOL	<input type="checkbox"/>	3200 OTHER	<input type="checkbox"/>					
INPUT TAPES			WORKING TAPES	OUTPUT TAPES			PERMANENT FASTRAND FILES	
UNIT	REEL NO.	FILE NAME		UNIT	REEL NO.	FILE NAME		
A PROGRAM TAPE								\$
								\$
F XXXXXX								\$
								\$
								\$
								\$
								\$
								\$
4080 <input type="checkbox"/>			REEL NO.	FILE NO.	PUNCHED OUTPUT <input type="checkbox"/>	REEL NO.	NO. CARDS	
18 MM <input type="checkbox"/> 35 MM <input type="checkbox"/>								
CAL COMP PLOT <input type="checkbox"/>			REEL NO.	NO. PLOTS	ACTUAL TIME USAGE			
ABNORMAL STOPS			SYSTEM OPERATOR		SYSTEM NO.		<div>STOP</div>	
EXCESS OUTPUT <input type="checkbox"/>					PAGES OUTPUT		<div>START</div>	
EXCESS TIME <input type="checkbox"/>								
OTHER (EXPLAIN BELOW) <input type="checkbox"/>								

ATTACHMENT 4

FLOW CHART





ATTACHMENT 5
PROGRAM LISTING

MAIN PROGRAM

STORAGE USED: CODE(1) 003717; DATA(0) 073316; BLANK COMMON(2) 000000

EXTERNAL REFERENCES (BLOCK, NAME)

0003 EXIT
0004 CMERR
0005 NINTRS
0006 NRDU5
0007 NI039
0010 NI029
0011 NWDUS
0012 NI019
0013 NERR29
0014 NRDU5
0015 NSTOP9
0016 DSQRT
0017 NERR45
0020 NERR39

ORIGINAL PAGE 19
OF 1008 QUALITY

STORAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

0001	000150	10L	0000	072335	1000F	0000	072336	1001F	0000	072340	1002F	0000	072341	1003F
0000	072343	1004F	0000	072346	1005F	0000	072350	1007F	0000	072352	1008F	0001	001727	1014G
0001	001741	1022G	0001	001750	1027G	0001	001774	1041G	0001	002006	1047G	0001	002015	1054G
0001	000677	110L	0001	002105	1103G	0001	002117	1111G	0001	002122	1114G	0001	002141	1125G
0001	002154	1134G	0001	002155	1137G	0001	002175	1153G	0001	000705	120L	0001	002375	1236G
0001	002407	1244G	0001	002416	1251G	0001	002446	1264G	0001	000724	130L	0001	003005	1371G
0001	003017	1377G	0001	000732	140L	0001	003026	1404G	0001	003072	1415G	0001	003076	1421G
0001	003157	1453G	0001	003171	1461G	0001	003200	1466G	0001	000743	150L	0001	003224	1500G
0001	003236	1506G	0001	003245	1513G	0001	003331	1537G	0001	003352	1550G	0001	003354	1553G
0001	003366	1562G	0001	000752	160L	0001	003446	1647G	0001	003504	1660G	0001	003513	1663G
0001	003545	1677G	0001	000757	170L	0001	003630	175L	0001	001003	190L	0001	000227	20L
0001	003632	200L	0000	072354	2000F	0000	072360	2001F	0000	072455	2002F	0000	072527	2003F
0000	072564	2004F	0000	072624	2005F	0000	072634	2006F	0000	072644	2007F	0000	072654	2008F
0000	072663	2009F	0000	072675	2010F	0000	072704	2011F	0000	072716	2012F	0000	072724	2013F
0000	072736	2014F	0000	072751	2015F	0000	072770	2016F	0000	072777	2017F	0000	073010	2018F
0000	073034	2019F	0000	073051	2020F	0000	073066	2021F	0000	073067	2022F	0000	073107	2023F
0001	001056	220L	0001	000243	221G	0001	000255	227G	0001	001075	230L	0001	000304	236G
0001	001112	240L	0001	000316	244G	0001	001121	250L	0001	000330	252G	0001	000342	260G
0001	001126	260L	0001	000353	266G	0001	001152	280L	0001	000261	30L	0001	000401	300G
0001	001170	300L	0001	000413	306G	0001	000422	313G	0001	001242	330L	0001	001267	340L
0001	001363	365L	0001	001424	370L	0001	001572	395L	0001	001614	400L	0000	073127	4001F
0000	073135	4002F	0000	073145	4003F	0000	073154	4004F	0000	073165	4005F	0001	000610	404G
0001	000611	407G	0001	001653	410L	0001	000654	426G	0001	002026	440L	0001	000717	444G
0001	001010	476G	0001	002207	480L	0001	002227	490L	0001	000445	50L	0001	002247	500L
0001	002355	510L	0001	001052	512G	0001	001070	523G	0001	002427	530L	0001	002453	540L
0001	002473	550L	0001	001165	560G	0001	002513	560L	0001	001175	566G	0001	002544	570L
0001	002557	575L	0001	002614	580L	0001	002656	590L	0001	000502	60L	0001	001235	600G
0001	002717	600L	0001	002761	610L	0001	001315	627G	0001	003037	630L	0001	001332	636G
0001	003131	640L	0001	001335	641G	0001	003137	650L	0001	001352	651G	0001	003256	680L

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0001	003270	490L	0001	000536	70L	0001	001473	705G	0001	001505	713G	0001	001514	720G
0001	003404	730L	0001	001540	732G	0001	001552	740G	0001	001561	745G	0001	001606	756G
0001	000555	80L	0001	003642	999L	0000	073210	9999F	0000	R 072255	B1GK	0000	R 072301	CESTOP
0000	R 072300	CESTRY	0000	R 072303	CON12	0000	R 072304	CON24	0000	R 072302	CON6	0000	R 072254	CP
0000	R 072130	DD	0000	R 065224	ERR	0000	R 072333	FAC	0000	I 072266	I	0000	I 072245	IBL
0000	I 072317	IDD	0000	I 072250	IEOF	0000	I 072311	IESTOP	0000	I 072310	IESTRY	0000	I 072315	IEVNT
0000	I 072320	IGOOD	0000	073247	INJPS	0000	I 072273	IOPT	0000	I 072263	IOPT1	0000	I 072305	IPAR
0000	I 072270	IX	0000	I 072271	IY	0000	I 072314	IYDD	0000	I 072321	II	0000	I 072323	I2
0000	I 072325	I3	0000	I 072267	J	0000	I 072247	JEQ	0000	I 072327	JI	0000	I 072330	J2
0000	I 072331	J3	0000	I 072252	LCDERR	0000	I 072313	LINES	0000	I 072307	LTEMP	0000	I 072251	LUIN
0000	I 072334	M	0000	I 072272	N	0000	I 072262	NCC	0000	I 072261	NCHS	0000	I 072316	NN
0000	I 072322	NNI	0000	I 072324	NN2	0000	I 072326	NN3	0000	I 072265	NOTH	0000	I 072264	NPAR
0000	I 072312	NPT	0000	I 072306	NSEN	0000	I 000174	NTCH	0000	I 072260	NTCLOC	0000	I 072277	NTME
0000	I 072244	NTSL	0000	I 072256	NX	0000	I 072257	NY	0000	R 022023	QDOT	0000	R 024726	QDOTMH
0000	R 010212	OX	0000	R 015116	OY	0000	R 072253	RHO	0000	D 072243	SERR	0000	D 072241	SIGMA
0000	D 072237	SLOPE	0000	R 072276	STATME	0000	D 072217	SUM1	0000	D 072221	SUM2	0000	D 072223	SUM3
0000	D 072225	SUM4	0000	D 072227	SUM5	0000	D 072231	SUM6	0000	D 072233	SUM7	0000	D 072235	SUM8
0000	R 005100	TEMP	0000	R 033632	TIM	0000	R 072132	TIME	0000	R 000000	TITLE1	0000	R 000014	TITLE2
0000	R 033714	TMP	0000	R 072275	TSTOP	0000	R 072274	TSTRY	0000	R 010130	WORD	0000	R 000030	XX
0000	R 072135	YDD	0000	R 000112	YY	0000	R 072332	YYD						

00100	1*	C	PROGRAM THNSKN	000000
00100	2*	C		000000
00100	3*	C	IDENTIFICATION	000000
00100	4*	C	TITLE - SURFACE HEATING RATE OF THIN SKIN MODELS	000000
00100	5*	C	PROGRAMMER - JACK D. MCBRYDE, LOCKHEED ELECTRONICS CO.	000000
00100	6*	C	DATE - OCTOBER 1969, REWRITTEN DECEMBER 1974	000000
00100	7*	C	INSTALLATION - NASA JSC HOUSTON TEXAS	000000
00100	8*	C		000000
00100	9*	C	DESCRIPTION	000000
00100	10*	C	THE PROGRAM COMPUTES THE HEATING RATE AT A NUMBER OF LOCATIONS	000000
00100	11*	C	ON THE SURFACE OF THIN SKIN TRANSIENT HEATING RATE MODELS.	000000
00100	12*	C		000000
00100	13*	C	EXPERIMENTAL DATA, CALIBRATED IN ENGINEERING UNITS, IS OBTAINED	000000
00100	14*	C	FROM THE ABEL TAPE OUTPUT OF THE EHTS03 DATA REDUCTION COMPUTER	000000
00100	15*	C	PROGRAM. THE PROGRAM OUTPUT CONSISTS OF TIME HISTORY TABULATION	000000
00100	16*	C	IN AN ARRAY BY THERMOCOUPLE LOCATIONS.	000000
00100	17*	C		000000
00100	18*	C		000000
00100	19*	C	B1GK - THERMAL CONDUCTIVITY (K) OF TEST MATERIAL (BTU/FT.SEC F)	000000
00100	20*	C	CESTOP - COMMAND EVENT CHANNEL STOP LEVEL INPUT (FLOATING POINT)	000000
00100	21*	C	CESTRY - COMMAND EVENT CHANNEL START LEVEL INPUT (FLOATING POINT)	000000
00100	22*	C	CON12 - RHO * CP / 12.	000000
00100	23*	C	CON24 - 24 * B1GK	000000
00100	24*	C	CON6 - RHO * CP / 6.	000000
00100	25*	C	CP - SPECIFIC HEAT OF TEST MATERIAL (BTU/FT.*2 SEC)	000000
00100	26*	C	DD(1) - SKIN THICKNESS OF TEST MATERIAL (INCHES)	000000
00100	27*	C	DD(2) - THE SECOND THICKNESS WHEN THE TEST MATERIAL HAS TWO	000000
00100	28*	C	ERR - PERCENT ERROR IN THE SLOPE	000000
00100	29*	C	I - USED TO DESIGNATE COORDINATE IN X-DIRECTION	000000
00100	30*	C	IDD - INDEX USED TO SPECIFY WHICH THICKNESS (DD) APPLIES	000000
00100	31*	C	IEOF - END OF FILE INDICATOR	000000
00100	32*	C	IESTOP - COMMAND EVENT CHANNEL STOP LEVEL (FIXED POINT)	000000
00100	33*	C	IESTRY - COMMAND EVENT CHANNEL START LEVEL (FIXED POINT)	000000

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00100	34	C	IEVNT	- CURRENT COMMAND EVENT CHANNEL VALUE	000000
00100	35	C	IGOOD	- IGOOD = 1 INDICATES WHEN THE FIRST SET OF 3 GOOD THERMO-	000000
00100	36	C		COUPLES IN A ROW OR COLUMN HAS BEEN FOUND IN LOGIC FOR	000000
00100	37	C		COMPUTING QX OR QY	000000
00100	38	C	IOPT	- RUN CONTROLLED BY 0 - START-STOP TIMES	000000
00100	39	C		1 - COMMAND CHANNEL EVENTS	000000
00100	40	C	IOPT1	- IOPT + 1	000000
00100	41	C	IPAR	- PARITY ERROR RECORD COUNTER	000000
00100	42	C	IX	- X-COORDINATE OF THERMOCOUPLE BEING DEFINED BY CHANNEL NO.	000000
00100	43	C	IY	- Y-COORDINATE OF THERMOCOUPLE BEING DEFINED BY CHANNEL NO.	000000
00100	44	C	IYDD	- THE Y COORDINATE INDEX JUST PRIOR TO THE CHANGE IN	000000
00100	45	C		MATERIAL THICKNESS	000000
00100	46	C	11,12,13	- THE INDICES FOR 3 SUCCESSIVE (BUT NOT NECESSARILY	000000
00100	47	C		ADJACENT) LOCATIONS OF GOOD THERMOCOUPLES IN THE X	000000
00100	48	C		DIRECTION	000000
00100	49	C	J	- USED TO DESIGNATE COORDINATES IN Y-DIRECTION	000000
00100	50	C	J1,J2,J3	- SAME AS 11,12,13 BUT IN Y DIRECTION	000000
00100	51	C	LCDERR	- LEAD CARD ERROR INDICATOR	000000
00100	52	C	LINES	- LINE COUNTER FOR PAGE EJECT CONTROL	000000
00100	53	C	LTEMP	- NUMBER OF LINES REQUIRED FOR ONE NX X NY ARRAY	000000
00100	54	C	LUIN	- LOGICAL UNIT FOR INPUT TAPE	000000
00100	55	C	NC	- THE MAXIMUM NUMBER OF CHANNELS THE INPUT TAPE MAY HAVE	000000
00100	56	C	NCC	- NUMBER OF COMMAND CHANNEL	000000
00100	57	C	NCHS	- NUMBER OF CHANNELS ON TAPE	000000
00100	58	C	NLS	- THE MAXIMUM NUMBER OF SCANS FOR WHICH LEAST SQUARES	000000
00100	59	C		COMPUTATIONS MAY BE DONE	000000
00100	60	C	NN	- CHANNEL NUMBER OF THERMOCOUPLE BEING PROCESSED	000000
00100	61	C	NN1,NN2,NN3	- CHANNEL NUMBERS OF THREE SUCCESSIVE GOOD THERMO-	000000
00100	62	C		COUPLES (QX OR QY COMPUTATIONS)	000000
00100	63	C	NOTH	- TIME HISTORY TAB OPTION. IF NOTH = 0, EACH SCAN OF DATA	000000
00100	64	C		FROM THE INPUT TAPE IN THE TIME INTERVAL WILL BE PRINTED.	000000
00100	65	C	NPAR	- MAXIMUM PERMISSIBLE NUMBER OF PARITY ERRORS PER TIME	000000
00100	66	C		SLICE	000000
00100	67	C	NPT	- NUMBER OF POINTS USED IN THE CURVE FIT	000000
00100	68	C	NSCN	- NUMBER OF SCANS OF DATA PROCESSED IN THE CURRENT TIME	000000
00100	69	C		SLICE	000000
00100	70	C	NTCH	- ARRAY OF THERMOCOUPLE CHANNEL NUMBERS	000000
00100	71	C	NTCLOC	- TOTAL NUMBER OF THERMOCOUPLE LOCATIONS (NX * NY)	000000
00100	72	C	NTME	- NUMBER OF POINTS REQUESTED FOR CURVE FIT	000000
00100	73	C	NTSL	- NUMBER OF TIME SLICES PROCESSED	000000
00100	74	C	NX	- NUMBER OF X-COORDINATE LOCATIONS	000000
00100	75	C	NY	- NUMBER OF Y-COORDINATE LOCATIONS	000000
00100	76	C	QDOT	- USED FOR MEAN HEATING RATE AND LEAST SQUARES HEATING RATE AT	000000
00100	77	C		DIFFERENT TIMES	000000
00100	78	C	QDOTMM	- THE SUMS (OR AVERAGES) OF THE QDOT VALUES FOR NTSL TIME	000000
00100	79	C		SLICES	000000
00100	80	C	QX	- MEAN LATERAL HEAT LOSS IN X DIRECTION	000000
00100	81	C	QY	- MEAN LATERAL HEAT LOSS IN Y DIRECTION	000000
00100	82	C	RHO	- MASS DENSITY OF TEST MATERIAL (LBM/FT**3)	000000
00100	83	C	SERR	- STANDARD ERROR OF THE SLOPE	000000
00100	84	C	SIGMA	- STANDARD DIVIATION SIGMA	000000
00100	85	C	SLOPE	- LEAST SQUARE SLOPE OR HEATING RATE	000000
00100	86	C	STATME	- START TIME FOR CURVE FIT	000000
00100	87	C	SUM1	- SUM X(I)*Y(I)	000000
00100	88	C	SUM2	- SUM X(I)	000000
00100	89	C	SUM3	- SUM Y(I)	000000
00100	90	C	SUM4	- SUM (X(I)**2)	000000

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00100	91.	C	SUM5	- SUM (Y(I)*2)	000000
00100	92.	C	SUM6	- (SUM X(I))*2	000000
00100	93.	C	SUM7	- SUM X(I) * SUM Y(I)	000000
00100	94.	C	SUM8	- NPT * SUM4 - SUM6	000000
00100	95.	C	TEMP	- TEMPI ,1) CONTAINS SUMMED (OR AVERAGED) TEMPERATURES	000000
00100	96.	C		TEMPI ,2) CONTAINS THE TEMPERATURES FOR SCAN 1	000000
00100	97.	C		TEMPI ,3) CONTAINS THE TEMPERATURES FOR SCAN 2	000000
00100	98.	C		TEMPI ,4) CONTAINS THE TEMPERATURES FOR SCAN NSCN - 1	000000
00100	99.	C		TEMPI ,5) CONTAINS THE TEMPERATURES FOR SCAN NSCN	000000
00100	100.	C		TEMPI ,6) CONTAINS THE TEMPERATURES JUST READ FROM TAPE	000000
00100	101.	C	TIM	- SAVED TIMES FOR CURVE FIT	000000
00100	102.	C	TIME	- TIME(1) IS THE FIRST TIME IN THE TIME SLICE	000000
00100	103.	C		TIME(2) IS THE LAST TIME IN THE TIME SLICE	000000
00100	104.	C		TIME(3) IS THE LAST TIME READ FROM TAPE	000000
00100	105.	C	TITLE1	- 1ST TITLE CARD	000000
00100	106.	C	TITLE2	- 2ND TITLE CARD	000000
00100	107.	C	TMP	- SAVED TEMPERATURES FOR CURVE FIT	000000
00100	108.	C	TSTOP	- COMPUTATIONAL STOP TIME	000000
00100	109.	C	TSTRT	- COMPUTATIONAL START TIME	000000
00100	110.	C	WORD	- INPUT TEMPERATURE VALUES FOR TAB OUTPUT	000000
00100	111.	C	XX	- X-COORDINATE LOCATIONS (INCHES)	000000
00100	112.	C	YDD	- THE Y COORDINATES OF JUNCTION POINTS BETWEEN THE TWO	000000
00100	113.	C		THICKNESSES OF TEST MATERIAL	000000
00100	114.	C	YY	- Y-COORDINATE LOCATIONS (INCHES)	000000
00100	115.	C			000000
00101	116.		PARAMETER NC=260,NLS=50		000000
00101	117.	C			000000
00103	118.		DIMENSION TITLE1(12), TITLE2(12), XX(50), YY(50), NTC(50,50)		000001
00104	119.		DIMENSION TEMP(NC,6),WORD(50),QX(50,50),QY(50,50),QDOT(50,50)		000001
00105	120.		DIMENSION QDOTMM(50,50),TIM(NLS),TMP(NC,NLS),ERR(50,50),DD(2)		000001
00106	121.		DIMENSION TIME(3),YDD(50)		000001
00106	122.	C			000001
00107	123.		DOUBLE PRECISION SUM1, SUM2, SUM3, SUM4, SUM5, SUM6, SUM7, SUM8		000001
00107	124.		I ,	SLOPE, SIGMA, SERR	000001
00107	125.	C			000001
00110	126.		DATA IBL /5H	/, NTSL /0/, JEQ /3HJ =/, IEOF /0/	000001
00115	127.		DATA LUIN/8/		000001
00115	128.	C			000001
00115	129.	C	INPUT SECTION		000001
00115	130.	C			000001
00115	131.	C	READ TITLE CARDS		000001
00117	132.		READ (5,1000)TITLE1		000001
00122	133.		READ (5,1000)TITLE2		000011
00125	134.		WRITE (6,2000)TITLE1,TITLE2		000021
00125	135.	C	READ CONSTANTS		000021
00131	136.		LCDErr = 0		000034
00132	137.		READ (5,1001)RHO,CP,BIGK,DD,NX,NY		000035
00142	138.		WRITE (6,2001)RHO,CP,BIGK,DD,NX,NY		000053
00152	139.		NTCLOC = NX * NY		000071
00153	140.		IF (NTCLOC.GT.3.AND.(NX.GE.3.OR.NY.GE.3).AND.NX.LE.50.AND.NY.LE.50		000074
00153	141.) GO TO 10		000074
00155	142.		WRITE (6,4001)		000140
00157	143.		LCDErr = 1		000145
00157	144.	C	READ TAPE INFORMATION		000145
00160	145.		10 READ(5,1002) NCHS,NCC,10PT1,NPAR,NOTH		000150
00167	146.		READ(30,1008) I		000161
00172	147.		IF(1.EQ.IBL) NPAR = 2		000167

00174	148.	IF (IOPT1.NE.0) IOPT1 = 1	000175
00176	149.	WRITE(6,2002) NCHS,NCC,IOPT1,NPAR,NOTH	000201
00205	150.	IF (NCHS-(NC-1)) 20,20,	000213
00210	151.	LCDERR = 1	000217
00211	152.	WRITE (6,4003)	000221
00213	153.	20 CONTINUE	000227
00214	154.	IF (DD(2)) 30,30,	000230
00217	155.	READ (5,1005)(YDD(I),I=1,NX)	000233
00225	156.	WRITE (6,2019)(YDD(I),I=1,NX)	000246
00233	157.	30 CONTINUE	000261
00233	158.	C READ X AND Y COORDINATE LOCATIONS	000261
00234	159.	READ (5,1005)(XX(I),I=1,NX)	000261
00242	160.	READ (5,1005)(YY(J),J=1,NY)	000307
00250	161.	WRITE (6,2005)(XX(I),I=1,NX)	000321
00256	162.	WRITE (6,2006)(YY(J),J=1,NY)	000333
00256	163.	C READ THERMOCOUPLE CHANNEL NUMBER AND	000333
00256	164.	C CORRESPONDING X-Y COORDINATES	000333
00264	165.	READ (5,1007)(IX,IY,NTCH(IX,IY),N=1,NTCLOC)	000345
00274	166.	WRITE(6,2007)	000365
00276	167.	WRITE(6,2022) (JEQ,J,J=1,NY)	000372
00305	168.	DO 40 I=1,NX	000413
00310	169.	WRITE (6,2008) I,(NTCH(I,J),J=1,NY)	000413
00317	170.	40 CONTINUE	000432
00317	171.	C READ START STOP TIMES OR EVENT LEVELS	000432
00321	172.	IOPT = IOPT1 + 1	000432
00322	173.	GO TO (50,60),IOPT	000435
00323	174.	50 READ (5,1003,END=690)TSTRT,TSTOP,STATME,NTME	000445
00331	175.	IF(NTSL.GT.0) WRITE(6,2021)	000456
00334	176.	WRITE (6,2003)TSTRT,TSTOP,STATME,NTME	000467
00342	177.	GO TO 70	000500
00343	178.	60 READ (5,1004,END=690)CESTRT,CESTOP,STATME,NTME	000502
00351	179.	IF(NTSL.GT.0) WRITE(6,2021)	000513
00354	180.	WRITE (6,2004)CESTRT,CESTOP,STATME,NTME	000524
00362	181.	70 IF (NTME.LE.NLS) GO TO 80	000536
00364	182.	I = NLS	000542
00365	183.	WRITE (6,4002) I	000544
00370	184.	LCDERR = 1	000552
00371	185.	80 CONTINUE	000555
00372	186.	IF (LCDERR) , ,730	000555
00372	187.	C	000555
00372	188.	C INITIALIZE AND DEFINE CONSTANTS	000555
00372	189.	C	000555
00375	190.	CON6 = RHO * CP / 24.	000557
00376	191.	CON12 = RHO * CP / 12.	000564
00377	192.	CON24 = BIGK * 24.	000567
00400	193.	IPAR = 0	000572
00401	194.	NSCN = 0	000573
00402	195.	LTEMP = ((NY+9) / 10) * NX + 5	000574
00403	196.	DO 90 I=1,NCHS	000611
00406	197.	DO 90 J=2,5	000611
00411	198.	90 TEMP(I,J) = 0.	000611
00414	199.	IESTRT = CESTRT	000616
00415	200.	IESTOP = CESTOP	000625
00416	201.	NPT = 0	000634
00417	202.	LINES = 1000	000635
00420	203.	IYDD = NY + 1	000637
00421	204.	IF (DD(2)) 110,110,	000642

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00424 205*      I = NY - 1
00425 206*      DO 100 J = 1, I
00430 207*      IF (YY(J).LE.YDD(1).AND.YY(J+1).GT.YDD(1)) YDD = J
00432 208*      100 CONTINUE
00434 209*      110 CONTINUE
00435 210*      TIME(1) = TIME(3)
00436 211*      IF (NTSL-1) ,150,150
00436 212*      C
00436 213*      C      READ INPUT TAPE
00436 214*      C
00441 215*      120 READ (LUIN,ERR=130,END=140)TIME(1),(TEMP(1,6),I=1,NCHS)
00450 216*      GO TO 150
00451 217*      130 WRITE (6,4004)
00453 218*      GO TO 120
00454 219*      140 WRITE (6,4005)LUIN
00457 220*      EOF = 1
00460 221*      GO TO 400
00461 222*      150 CONTINUE
00462 223*      GO TO (160,170),10PT
00463 224*      160 IF (TIME(1)-TSTRT) 120,190,190
00466 225*      170 IEVNT = TEMP(NCC,6) + 0.5
00467 226*      IF (IEVNT-(TESTRT+2)) 180,190,120
00472 227*      180 IF (IEVNT-(TESTRT-2)) 120,190,190
00472 228*      C      STARTING TIME FOUND
00475 229*      190 DO 200 I=1,NCHS
00500 230*      TEMP(I,1) = TEMP(I,6)
00501 231*      200 TEMP(I,2) = TEMP(I,6)
00503 232*      TIME(2) = TIME(1)
00504 233*      NSCN = 1
00505 234*      IF (NTME.LE.2.OR.TIME(1).LT.STATME) GO TO 330
00507 235*      NPT = NPT + 1
00510 236*      TIM(NPT) = TIME(1)
00511 237*      DO 210 I=1,NCHS
00514 238*      210 TMP(I,NPT) = TEMP(I,6)
00516 239*      GO TO 330
00517 240*      220 CONTINUE
00520 241*      READ (LUIN,ERR=230,END=140)TIME(3),(TEMP(1,6),I=1,NCHS)
00527 242*      GO TO 240
00530 243*      230 IPAR = IPAR + 1
00531 244*      WRITE (6,4004)
00533 245*      IF (IPAR-NPAR) 220,220,730
00536 246*      240 CONTINUE
00537 247*      GO TO (250,260),10PT
00540 248*      250 IF (TIME(3)-TSTOP) 280,280,400
00543 249*      260 IEVNT = TEMP(NCC,6) + .5
00544 250*      IF (IEVNT-(TESTOP+2)) 270,270,280
00547 251*      270 IF (IEVNT-(TESTOP-2)) 280,400,400
00552 252*      280 TIME(2) = TIME(3)
00553 253*      NSCN = NSCN + 1
00554 254*      IF (NSCN=2) 300,,300
00557 255*      DO 290 I=1,NCHS
00562 256*      290 TEMP(I,3) = TEMP(I,6)
00564 257*      300 CONTINUE
00565 258*      DO 310 I=1,NCHS
00570 259*      TEMP(I,4) = TEMP(I,5)
00571 260*      TEMP(I,5) = TEMP(I,6)
00572 261*      310 TEMP(I,1) = TEMP(I,1) + TEMP(I,6)

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00574	262*		IF (NTME.LE.2.OR.TIME(2).LT.STATME) GO TO 330	001204
00576	263*		NPT = NPT + 1	001222
00577	264*		DO 320 I=1,NCHS	001225
00602	265*	320	TMP(I,NPT) = TEMP(I,6)	001235
00604	266*		TIM(NPT) = TIME(2)	001237
00605	267*	330	CONTINUE	001242
00606	268*		IF (NOTH) , , 365	001242
00611	269*		IF (LINES+LTEMP-55) 340,340,	001244
00614	270*		WRITE (6,2000)TITLE1,TITLE2	001251
00620	271*		LINES = 3	001264
00621	272*	340	CONTINUE	001267
00622	273*		WRITE (6,2013)TIME(2)	001267
00625	274*		WRITE(6,2023) (JEQ,J,J=1,NY)	001303
00634	275*		LINES = LINES + LTEMP	001323
00635	276*		DO 360 I=1,NX	001335
00640	277*		DO 350 J=1,NY	001335
00643	278*		NN = NCH(I,J)	001335
00644	279*	350	WORD(J) = TEMP(NN,6)	001336
00646	280*		WRITE (6,2010)I,WORD(J),J=1,NY)	001342
00655	281*	360	CONTINUE	001363
00657	282*	365	CONTINUE	001363
00657	283*	C		001363
00657	284*	C	DO ERROR ANALYSIS IF 'NTME' POINTS HAVE BEEN SAVED	001363
00657	285*	C		001363
00660	286*		IF (NTME.LE.2.OR.NPT.LT.NTME) GO TO 220	001363
00662	287*		IF (LINES+2*LTEMP-59) 370,370,	001400
00665	288*		LINES = 3	001406
00666	289*		WRITE (6,2000)TITLE1,TITLE2	001410
00672	290*	370	WRITE (6,2015)NPT,TIM(I),TIM(NPT)	001424
00677	291*		LINES = LINES + 2 * LTEMP - 3	001436
00700	292*		CALL ERRFIT(5395)	001442
00700	293*	C		001442
00700	294*	C	OUTPUT HEATING RATE - QDOT AND PERCENT ERROR - ERR	001442
00700	295*	C		001442
00701	296*		WRITE(6,2012)	001445
00703	297*		WRITE(6,2023) (JEQ,J,J=1,NY)	001452
00712	298*		DO 380 I=1,NX	001505
00715	299*		WRITE (6,2010)I,(QDOT(I,J),J=1,NY)	001505
00724	300*	380	CONTINUE	001524
00726	301*		WRITE (6,2016)	001524
00730	302*		WRITE(6,2023) (JEQ,J,J=1,NY)	001531
00737	303*		DO 390 I=1,NX	001552
00742	304*		WRITE (6,2010)I,(ERR(I,J),J=1,NY)	001552
00751	305*	390	CONTINUE	001572
00753	306*	395	CONTINUE	001572
00754	307*		TIM(I) = TIM(NPT)	001572
00755	308*		DO 396 I = 1, NCHS	001606
00760	309*	396	TMP(I,1) = TMP(I,NPT)	001606
00762	310*		NPT = 1	001610
00763	311*		GO TO 220	001612
00763	312*	C		001612
00763	313*	C	THE TIME SLICE HAS BEEN COMPLETED OR AN END OF FILE ENCOUNTERED	001612
00763	314*	C		001612
00764	315*	400	CONTINUE	001614
00765	316*		IF (NTME.LE.2.OR.NPT.LT.3) GO TO 440	001614
00767	317*		IF (LINES+2*LTEMP-59) 410,,	001631
00772	318*		WRITE (6,2000)TITLE1,TITLE2	001637

00776	319*		410 CONTINUE	001653
00777	320*		WRITE (6,2015)NPT,TIM(1),TIM(NPT)	001653
01004	321*		IF (NPT.LT.NTME) WRITE (6,2017)	001664
01004	322*	C		001664
01004	323*	C	COMPUTE AND PRINT LEAST SQUARES HEATING RATE (QDOT) AND PERCENT	001664
01004	324*	C	ERROR (ERR)	001664
01007	325*		CALL ERRFIT(5440)	001676
01010	326*		WRITE(6,2012)	001701
01012	327*		WRITE(6,2023) (JEQ,J,J=1,NY)	001706
01021	328*		DO 420 I=1,NX	001741
01024	329*		WRITE (6,2010)I,(QDOT(I,J),J=1,NY)	001741
01033	330*		420 CONTINUE	001760
01035	331*		WRITE (6,2016)	001760
01037	332*		WRITE(6,2023) (JEQ,J,J=1,NY)	001765
01046	333*		DO 430 I=1,NX	002004
01051	334*		WRITE (6,2010)I,(ERR(I,J),J=1,NY)	002004
01060	335*		430 CONTINUE	002026
01060	336*	C		002026
01062	337*		440 CONTINUE	002026
01063	338*		IF (NSCN-3) 680,,	002026
01066	339*		NTSL = NTSL + 1	002031
01067	340*		LINES = 1000	002045
01070	341*		WRITE (6,2000)TITLE1,TITLE2	002047
01074	342*		WRITE (6,2018)NSCN,TIME(1),TIME(2)	002064
01101	343*		WRITE(6,2023) (JEQ,J,J=1,NY)	002074
01110	344*		DO 460 I=1,NX	002122
01113	345*		DO 450 J=1,NY	002122
01116	346*		NN = NTCH(I,J)	002122
01117	347*		TEMP(NN,1) = TEMP(NN,1) / NSCN	002123
01120	348*		450 WORD(J) = TEMP(NN,1)	002127
01122	349*		WRITE (6,2010)I,(WORD(J),J=1,NY)	002131
01131	350*		460 CONTINUE	002155
01131	351*	C		002155
01131	352*	C	PROCESS LATERAL HEAT LOSS IN X-DIRECTION (EQUATION 3)	002155
01131	353*	C		002155
01133	354*		DO 470 I=1,NX	002155
01136	355*		DO 470 J=1,NY	002155
01141	356*		QX(I,J) = 0.	002155
01142	357*		QY(I,J) = 0.	002155
01143	358*		470 QDOT(I,J) = 0.	002156
01146	359*		IF (NX-2) 530,530,,	002164
01151	360*		IDD = 1	002170
01152	361*		DO 510 J=1,NY	002175
01155	362*		IGOOD = 0	002175
01156	363*		IF(J,GT.1YDD) IDD = 2	002176
01160	364*		I1 = 0	002205
01161	365*		480 I1 = I1 + 1	002207
01162	366*		IF (I1+2-NX) ,510	002211
01165	367*		NN1 = NTCH(I1,J)	002215
01166	368*		IF (NN1) 480,480,,	002222
01171	369*		I2 = I1	002224
01172	370*		490 I2 = I2 + 1	002227
01173	371*		IF (I2+1-NX) ,510	002231
01176	372*		NN2 = NTCH(I2,J)	002235
01177	373*		IF (NN2) 490,490,,	002242
01202	374*		I3 = I2	002244
01203	375*		500 I3 = I3 + 1	002247

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01204	376.		IF (I3-NX) ,510	
01207	377.		NN3 = NTCH(I3,J)	
01210	378.		IF (NN3) 500,500,	
01213	379.		IGOOD = IGOOD + 1	
01214	380.		QX(I2,J) = CON24 * DD(I00) / (XX(I3) - XX(I1)) * ((TEMP(NN2,I) -	
01214	381.		TEMP(NN1,I)) / (XX(I2) - XX(I1)) - (TEMP(NN3,I) -	
01214	382.		TEMP(NN2,I)) / (XX(I3) - XX(I2))	
01215	383.		QX(I3,J) = QX(I2,J)	
01216	384.		IF (IGOOD.EQ.1) QX(I1,J) = QX(I2,J)	
01220	385.		IF (I3-NX) ,510,510	
01223	386.		NN1 = NN2	
01224	387.		NN2 = NN3	
01225	388.		I1 = I2	
01226	389.		I2 = I3	
01227	390.		GO TO 500	
01230	391.	510	CONTINUE	
01232	392.		WRITE (6,2009)	
01234	393.		WRITE(6,2023) (JEQ,J,J=1,NY)	
01243	394.		DO 520 I=1,NX	
01246	395.		WRITE (6,2010) I, (QX(I,J),J=1,NY)	
01255	396.	520	CONTINUE	
01257	397.	530	CONTINUE	
01257	398.	C		
01257	399.	C	PROCESS LATERAL HEAT LOSS IN Y-DIRECTION	
01257	400.	C		
01260	401.		IF (NY-2) 630,630,	
01263	402.		DO 610 I=1,NX	
01266	403.		IGOOD = 0	
01267	404.		I00 = 1	
01270	405.		J1 = 0	
01271	406.	540	J1 = J1 + 1	
01272	407.		IF (J1+2-NY) ,610	
01275	408.		NN1 = NTCH(I,J1)	
01276	409.		IF (NN1) 540,540,	
01301	410.		J2 = J1	
01302	411.	550	J2 = J2 + 1	
01303	412.		IF (J2+1-NY) ,610	
01306	413.		NN2 = NTCH(I,J2)	
01307	414.		IF (NN2) 550,550,	
01312	415.		J3 = J2	
01313	416.	560	J3 = J3 + 1	
01314	417.		IF (J3-NY) ,610	
01317	418.		NN3 = NTCH(I,J3)	
01320	419.		IF (NN3) 560,560,	
01323	420.		IGOOD = IGOOD + 1	
01324	421.		IF (J2-IYDD) ,580,570	
01327	422.		IF (J3-IYDD) 575,575,580	
01332	423.	570	IF (J2-(IYDD+1)) 590,590,	
01335	424.		IF (J1-IYDD) 590,590,	
01340	425.		I00 = 2	
01341	426.	575	QY(I,J2) = CON24 * DD(I00) / (YY(J3) - YY(J1)) * ((TEMP(NN2,I) -	
01341	427.		TEMP(NN1,I)) / (YY(J2) - YY(J1)) - (TEMP(NN3,I) -	
01341	428.		TEMP(NN2,I)) / (YY(J3) - YY(J2))	
01342	429.		GO TO 600	
01343	430.	580	YYD = YDD(I)	
01344	431.		QY(I,J2) = CON24 * DD(I) / (YY(J3)-YY(J1)) * ((TEMP(NN2,I) -	
01344	432.		TEMP(NN1,I)) / (YY(J2)-YY(J1)) - DD(2)*(TEMP(NN3,I) -	

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01344	433.	.	TEMP(NN2,1) / (DD(2)*(YYD - YY(J2)) + DD(1)*(YY(J3) - YY(J1)))	002615
01344	434.	.	- YYD(J1)	002615
01345	435.	.	GO TO 600	002654
01346	436.	590	YYD = YDD(I)	002656
01347	437.	.	QY(I,J2) = CON24 * DD(2) / (YY(J3)-YY(J1)) * (DD(1)*(TEMP(NN2,1) -	002657
01347	438.	.	TEMP(NN1,1)) / (DD(2)*(YYD - YY(J1)) + DD(1)*(YY(J2) -	002657
01347	439.	.	YYD)) - (TEMP(NN3,1) - TEMP(NN2,1)) / (YY(J3)-YY(J2)))	002657
01350	440.	600	QY(I,J3) = QY(I,J2)	002717
01351	441.	.	IF (IGOOD.EQ.1) QY(I,J1) = QY(I,J2)	002726
01353	442.	.	IF (J3-NY) ,610,610	002743
01356	443.	.	NN1 = NN2	002747
01357	444.	.	NN2 = NN3	002751
01360	445.	.	J1 = J2	002753
01361	446.	.	J2 = J3	002755
01362	447.	.	GO TO 560	002757
01363	448.	610	CONTINUE	002762
01365	449.	.	WRITE (6,2011)	002762
01367	450.	.	WRITE(6,2023) (JEQ,J,J=1,NY)	002767
01376	451.	.	DO 620 I=1,NX	003017
01401	452.	.	WRITE (6,2010) I,(QY(I,J),J=1,NY)	003017
01410	453.	620	CONTINUE	003037
01412	454.	630	CONTINUE	003037
01412	455.	C	.	003037
01412	456.	C	COMPUTE Q (ARRAY ERR IS USED) IF QX AND QY NOT BOTH ZERO	003037
01412	457.	C	.	003037
01413	458.	.	FAC = CON6 / (TIME(2) - TIME(1)) * (NSCN-1) / (NSCN-2)	003037
01414	459.	.	DO 650 I=1,NX	003072
01417	460.	.	IDD = 1	003072
01420	461.	.	DO 650 J=1,NY	003076
01423	462.	.	IF (J.GT.IYDD) IDD = 2	003105
01425	463.	.	NN = NTCN(I,J)	003110
01426	464.	.	ERR(I,J) = U.	003111
01427	465.	.	IF (NN) 650,650,	003114
01432	466.	.	ERR(I,J) = FAC * DD(IDD) * (TEMP(NN,5) + TEMP(NN,4) - TEMP(NN,2) -	003114
01432	467.	.	TEMP(NN,3))	003124
01433	468.	.	IF (QX(I,J)) 640,640	003126
01436	469.	.	IF (QY(I,J)) 640,650,640	003131
01441	470.	640	CONTINUE	003131
01442	471.	.	QDOT(I,J) = ERR(I,J) + QX(I,J) + QY(I,J)	003134
01443	472.	.	QDOTMH(I,J) = QDOTMH(I,J) + QDOT(I,J)	003143
01444	473.	650	CONTINUE	003150
01447	474.	.	WRITE (6,2014)	003171
01451	475.	.	WRITE(6,2023) (JEQ,J,J=1,NY)	003171
01460	476.	.	DO 660 I=1,NX	003210
01463	477.	.	WRITE (6,2010) I,(ERR(I,J),J=1,NY)	003215
01472	478.	660	CONTINUE	003236
01474	479.	.	WRITE (6,2012)	003256
01476	480.	.	WRITE(6,2023) (JEQ,J,J=1,NY)	003256
01505	481.	.	DO 670 I=1,NX	003260
01510	482.	.	WRITE (6,2010) I,(QDOT(I,J),J=1,NY)	003260
01517	483.	670	CONTINUE	003270
01521	484.	680	IF (TEOF) ,690	
01524	485.	.	GO TO (50,60),10PT	
01524	486.	C	.	
01524	487.	C	COMPUTE AND PRINT MEANS OF MEAN HEATING RATES.	
01524	488.	C	.	
01525	489.	690	CONTINUE	

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01526	490.	WRITE (6,2000)TITLE1,TITLE2	003270
01532	491.	WRITE (6,2020)NTSL	003302
01535	492.	WRITE(6,2023) (JEQ,J:J=1,NY)	003317
01544	493.	IF (NTSL) 730,730,	003337
01547	494.	DO 710 I=1,NX	003342
01552	495.	DO 700 J=1,NY	003354
01555	496.	700 QDOTMM(I,J) = QDOTMM(I,J) / NTSL	003354
01557	497.	WRITE (6,2010)I,(QDOTMM(I,J),J=1,NY)	003357
01566	498.	710 CONTINUE	003401
01570	499.	720 CALL EXIT	003401
01570	500.	C	003401
01571	501.	730 CALL CHERR	003404
01571	502.	C	003404
01571	503.	C FORMAT STATEMENTS	003404
01571	504.	C	003404
01572	505.	1000 FORMAT (12A6)	003407
01573	506.	1001 FORMAT(5F10.3,2I3)	003407
01574	507.	1002 FORMAT (7I5)	003407
01575	508.	1003 FORMAT(3F10.3,15)	003407
01576	509.	1004 FORMAT(2F10.0,F10.3,15)	003407
01577	510.	1005 FORMAT (5F10.3)	003407
01600	511.	1007 FORMAT (5(2I3,14))	003407
01601	512.	1008 FORMAT(15X,A5)	003407
01602	513.	2000 FORMAT (11H1/16X,12A6/16X,12A6)	003407
01603	514.	2001 FORMAT(11H0,15X,'MASS DENSITY OF TEST MATERIAL (RHO) =',F12.4	003407
01603	515.	5X,'SPECIFIC HEAT OF TEST MATERIAL (CP) =',F12.4	003407
01603	516.	/ 16X,'THERMAL CONDUCTIVITY (BIGK) =',F12.4	003407
01603	517.	5X,'THICKNESS OF TEST MATERIAL (DD1) =',F12.4	003407
01603	518.	/ 16X,'THICKNESS OF TEST MATERIAL (DD2) =',F12.4	003407
01603	519.	5X,'NUMBER OF X-COORDINATES (NX) =',I12	003407
01603	520.	/ 16X,'NUMBER OF Y-COORDINATES (NY) =',I12	003407
01603	521.	//	003407
01604	522.	2002 FORMAT(16X,'NUMBER OF CHANNELS ON TAPE (NCHS) =',I12	003407
01604	523.	5X,'COMMAND CHANNEL NUMBER (NCC) =',I12	003407
01604	524.	/ 16X,'TIME INTERVAL OR EVENT CODE (IOPT1) =',I12	003407
01604	525.	5X,'ACCEPTABLE NO. OF PARITIES (NPAR) =',I12	003407
01604	526.	/ 16X,'TIME HISTORY TAB OPTION (NOTH) =',I12	003407
01604	527.	//	003407
01605	528.	2003 FORMAT(11H0,15X,'START TIME =',F10.3,' STOP TIME =',F10.3 /	003407
01605	529.	16X,'LEAST SQUARES START TIME =',F10.3,' NO OF POINTS FOR '	003407
01605	530.	'LEAST SQUARES COMPUTATIONS (NTME) =',I10)	003407
01606	531.	2004 FORMAT(11H0,15X,'COMMAND EVENT START LEVEL =',F12.4,5X,'STOP LEVEL'	003407
01606	532.	,, =',F12.4/	003407
01606	533.	16X,'LEAST SQUARES START TIME =',F10.3,' NO OF POINTS FOR '	003407
01606	534.	'LEAST SQUARES COMPUTATIONS (NTME) =',I10)	003407
01607	535.	2005 FORMAT (11H0,15X,'X-COORDINATES ...'(21X,10F10.3))	003407
01610	536.	2006 FORMAT (11H0,15X,'Y-COORDINATES ...'(21X,10F10.3))	003407
01611	537.	2007 FORMAT (11H0,15X,'INPUT TAPE CHANNEL NUMBERS ...')	003407
01612	538.	2008 FORMAT (11H 15X,'I = ',I2,10I10,(/22X,10I10))	003407
01613	539.	2009 FORMAT(11H0,10X,'MEAN LATERAL HEAT LOSS IN X-DIRECTION ...')	003407
12 01614	540.	2010 FORMAT (11H 5X,'I =',I3,10F10.3/(12X,10F10.3/))	003407
01615	541.	2011 FORMAT(11H0,10X,'MEAN LATERAL HEAT LOSS IN Y-DIRECTION ...')	003407
10 01616	542.	2012 FORMAT(11H0,10X,'MEAN HEATING RATE ...')	003407
01617	543.	2013 FORMAT (11H0,10X,'TIME =',F10.3/711X,'CURRENT TEMPERATURE ...')	003407
8 01620	544.	2014 FORMAT(11H0,10X,'MEAN HEAT FLUX WITHOUT CONDUCTION CORRECTION ...')	003407
7 01621	545.	2015 FORMAT (11H0,10X,'LINEAR CURVE FIT USING ',I3,' POINTS. TIME =',	003407
6 01621	546.	'F10.3,' TO',F10.3,' SEC')	003407

01622	547*	2016 FORMAT (1H0,10X,'PERCENT STANDARD ERROR ...')	003407
01623	548*	2017 FORMAT (1H*,T89,'... FEWER POINTS THAN REQUESTED ...')	003407
01624	549*	2018 FORMAT(1H0,10X,'TEMPERATURES AVERAGED OVER',15,' POINTS. TIME IN'	003407
01624	550*	.., 'TERVAL PROCESSED',F10.3,' TO',F10.3,' SEC')	003407
01625	551*	2019 FORMAT(1H0,15X,'Y-COORDINATES OF THICKNESS DIFFERENCE JUNCTION...'	003407
01625	552*	.., (721X,10F10.3))	003407
01626	553*	2020 FORMAT(1H0,10X,'MEANS OF MEAN HEATING RATES FOR',13,' TIME PERIOD'	003407
01626	554*	.., 'S...')	003407
01627	555*	2021 FORMAT(1H1)	003407
01630	556*	2022 FORMAT	003407
01630	557*	.. (28X,A3,12,5X,A3,12,5X,A3,12,5X,A3,12,5X,A3,12,5X,A3,12,5X,A3,12,	003407
01630	558*	..5X,A3,12,5X,A3,12,5X,A3,12)	003407
01631	559*	2023 FORMAT	003407
01631	560*	.. (17X,A3,12,5X,A3,12,5X,A3,12,5X,A3,12,5X,A3,12,5X,A3,12,5X,A3,12,	003407
01631	561*	..5X,A3,12,5X,A3,12,5X,A3,12)	003407
01632	562*	4001 FORMAT(1X,'... ERROR - NX OR NY IS BAD')	003407
01633	563*	4002 FORMAT(1X,'... ERROR - NTIME IS LARGER THAN ',13)	003407
01634	564*	4003 FORMAT(1X,'... ERROR - TOO MANY CHANNELS')	003407
01635	565*	4004 FORMAT(1H0,10X,'... PARITY ERROR RECORD DELETED ...')	003407
01636	566*	4005 FORMAT(1H0,10X,'END OF FILE ENCOUNTERED ON UNIT ',12,' PROCESSING'	003407
01636	567*	.., ' OF ACCUMULATED DATA WILL BE ATTEMPTED.')	003407
01636	568*	C	003407
01636	569*	C.....	003407
01636	570*	C.....	003407
01636	571*	C	003407
01637	572*	SUBROUTINE ERRFIT(S)	003407
01637	573*	C	003407
01637	574*	C SUBROUTINE TO COMPUTE THE HEATING RATE BY FITTING A GIVEN TIME	003407
01637	575*	C INTERVAL OF DATA TO A FIRST DEGREE POLYNOMIAL AND TO COMPUTE	003407
01637	576*	C THE STANDARD AND PERCENT ERROR OF THIS HEATING RATE.	003407
01637	577*	C	003407
01642	578*	IF (NPT.LE.2) GO TO 999	003407
01642	579*	C	003407
01644	588*	SUM2 = 0.0	003414
01645	581*	4 SUM4 = 0.0	003416
01646	582*	DO 125 M = 1,NPT	003446
01646	583*	C SUM X(I)	003446
01651	584*	SUM2 = SUM2 + TIM(M)	003446
01651	585*	C SUM (X(I)**2)	003446
01652	586*	SUM4 = SUM4 + TIM(M)**2	003451
01653	587*	125 CONTINUE	003456
01653	588*	C (SUM X(I))**2	003456
01655	589*	SUM6 = SUM2**2	003456
01656	590*	SUM8 = NPT * SUM4 - SUM6	003460
01656	591*	C	003460
01657	592*	DO 200 I = 1,NX	003464
01662	593*	DO 200 J = 1,NY	003513
01665	594*	IDD = 1	003513
01666	595*	IF (J.GT.1YDD) IDD = 2	003515
01670	596*	NN = NYCHT(I,J)	003524
01671	597*	IF (NN.LE.0) GO TO 175	003526
01673	598*	SUM1 = 0.0	003532
01674	599*	SUM3 = 0.0	003534
01675	600*	SUM5 = 0.0	003535
01676	601*	DO 150 M = 1,NPT	003545
01676	602*	C SUM Y(I)*Y(I)	003545
01701	603*	SUM1 = SUM1 + TIM(M) * TMP(NN,M)	003545

01701	604*	C	SUM Y(I)	003545
01702	605*		SUM3 = SUM3 + TMP(NN,M)	003552
01702	606*	C	SUM (Y(I)**2)	003552
01703	607*		SUM5 = SUM5 + TMP(NN,M)**2	003555
01704	608*		150 CONTINUE	003562
01704	609*	C	SUM X(I) * SUM Y(I)	003562
01706	610*		SUM7 = SUM2 * SUM3	003562
01706	611*	C	SLOPE	003562
01707	612*		SLOPE = (NPT * SUM1 - SUM7) / SUM8	003564
01707	613*	C	SIGMA	003564
01710	614*		SIGMA = 1.0 / NPT * SQRT(NPT * SUM5 - SUM3**2	003573
01710	615*		1 - (NPT * SUM1 - SUM7)**2 / SUM6)	003573
01710	616*	C	STANDARD ERROR	003573
01711	617*		SERR = NPT * SIGMA / SQRT((NPT-2) * SUM8)	003612
01711	618*	C	PERCENT ERROR	003612
01712	619*		ERR(I,J) = SERR / SLOPE * 100.0	003619
01712	620*	C	HEATING RATE	003619
01713	621*		QDOT(I,J) = CON12 * DD(1DD) * SLOPE	003621
01714	622*		GO TO 200	003626
01715	623*		175 ERR(I,J) = 0.0	003630
01716	624*		QDOT(I,J) = 0.0	003630
01717	625*		200 CONTINUE	003636
01722	626*		RETURN	003636
01722	627*	C		003636
01723	628*		999 WRITE (6,9999)	003642
01725	629*		9999 FORMAT (1H0,10X,'TOO FEW POINTS AVAILABLE FOR CURVE FIT.')	003646
01726	630*		RETURN	003646
01726	631*	C		003646
01727	632*		END	003716

END OF COMPILATION: NO DIAGNOSTICS.

QCOPOUT TPF5.,THNSKN.
FURPUR 0026-12/20-03:02

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ATTACHMENT 6

SAMPLE INPUT

(TO BE SUPPLIED LATER)

ATTACHMENT 7

SAMPLE OUTPUT

(TO BE SUPPLIED LATER)

ATTACHMENT 8

CORRESPONDENCE

THIS FORM MUST BE COMPLETED BY TYPEWRITER

01 4 JSC		01 7 PROGRAM NO Q614		JSC COMPUTER PROGRAM ABSTRACT				01 14 DATE (MMDDYY) 1-21-75			
01 20 TITLE OF PROGRAM (62 CHARACTERS MAXIMUM) SURFACE HEATING RATE OF THIN SKIN MODELS				01 72 SYMBOLIC NAME (9 CHARACTERS MAXIMUM) THNSKN		PARENT PROGRAM					
02 26 CAT-EGORY		02 27 LANGUAGE NO. 1		02 32 LANGUAGE NO. 2		02 37 KEY WORDS (8 MAXIMUM SEPARATED BY COMMAS) Arc Jet, Heat Rate, Thin Skin, Thermocouples					
FOR V											
WHOM TO CONTACT ABOUT THE PROGRAM						05 48 STATUS		05 49			
05 14 CONTACT (LAST NAME) Stephenson		05 28 SITE JSC		05 31 ORGN CODE FD57		05 39 PROJECT NO 4300		05 45 NASA CENTER			
						<input type="checkbox"/> A. UNDER DEVELOPMENT <input type="checkbox"/> B. OPERATIONAL <input checked="" type="checkbox"/> C. COMPLETED		<input type="checkbox"/> A. THIS PROGRAM IS NOT FOR SHARING <input type="checkbox"/> B. LIMITED SHARING (SEE ABSTRACT)			
DATES		05 58 REVISION CODE		TIME AND COST FOR DEVELOPMENT							
05 50 INITIATED MMY 11-74		05 54 COMPLETED MMY 12-74		<input checked="" type="checkbox"/> A. REVISION <input type="checkbox"/> B. CANCELLATION		05 59 MAN-MONTHS 8		05 64 MACHINE HOURS 2 0			
						05 69 COMPUTER TYPE 1108		05 74 TOTAL COST (DOLLARS)			
								74 75 76 77 78 79 80			
CARD NUMBER		ABSTRACT						ELITE MARGIN		PICA MARGIN	
06		THNSKN computes the mean heating rate at up to 100									
07		locations on the surface of thin skin transient									
08		heating rate models. Output is printed in tabular									
09		form and consists of time history tabulation of									
10		temperatures, average temperatures, heat loss									
11		without conduction correction, mean heating rate,									
12		least squares heating rate, and the percent standard									
13		error of the least squares heating rates. The input									
14		tape used is produced by the program EHTS03.									
15		(SCR 83-15-30/McBryde)									
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RELATED DOCUMENTATION (66 CHARACTERS MAXIMUM SEPARATE EACH REF BY COMMAS)											
42											

UNITED STATES GOVERNMENT

Memorandum

Computation and Analysis Division
NASA Manned Spacecraft Center
Houston, Texas 77058

TO : LEC/Manager, Test Data Reduction
Department, 672-10

DATE: October 27, 1969

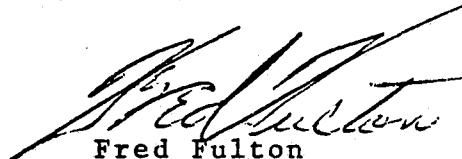
FROM : ED5/Acting Chief, Data Processing Branch

In reply refer to:
11-69-622

SUBJECT: Requirements for a Thin Skin Transient Heating Rate Model
Program

Programing support is required to develop a program to compute heating rates of thin skin transient heating rate models. This program will be developed for the Experimental Heat Transfer Section of the Structures and Mechanics Division. The program will be used to support definition of the aerothermodynamic design of the MSC space shuttle vehicle.

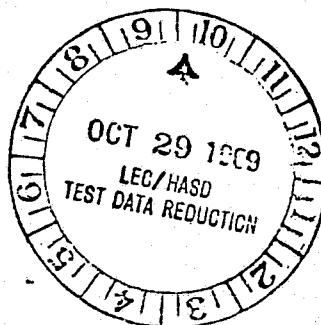
It is necessary that the program, specified by the attached requirements document, be operation by October 31, 1969. Preliminary requirements have been reviewed by Dr. Carl D. Scott, project engineer, and forwarded to Mrs. Yvonne Chempinski. Work on this task should be charged to project number 4556. For further information, please contact Mr. E. O. Grice, extension 5533.


Fred Fulton

Enclosure

cc:
ES56/Dr. C. D. Scott

ED57:EOGrice(LEC:JMRandal):ddc 10-27-69



DATA PROCESSING REQUIREMENTS
for a
THIN SKIN TRANSIENT HEATING RATE MODEL PROGRAM

Prepared by:

J. M. Randal
J. M. Randal 22 Oct 69
LEC Requirements & Analysis

Approved by:

K. J. Langenberg
K. J. Langenberg 10-24
LEC Requirements & Analysis

Concurrence by:

E. O. Grice
E. O. Grice 10/23/69
CAD Requirements & Analysis

Concurrence by:

Carl D. Scott
Carl D. Scott 10/22/69
Experimental Heat Transfer Section

PROJECT DISCUSSION

The Experimental Heat Transfer Section of the Structures and Mechanics Division has requirements for a digital computer program to compute heating rates of thin skin transient heating rate models. These models will be tested in either the 1.5 Megawatt or the 10 Megawatt Arc-Heater facility. The tests in which such models will be used will be directly related to current MSC space shuttle vehicle activities. The program outputs will be used to support definition of the aerothermodynamic design of the MSC space shuttle vehicle configuration.

TEST CONFIGURATION

The thin skin transient heating rate models will be constructed with a thin metal skin. Thermocouple instrumentation will be attached to the back side of the skin in rectangular arrays and used to measure temperature. When these models are subjected to a non-uniform constant heat flux by the arc-heater equipment, the surface temperature of the skin will increase according to the laws of heat conduction and capacitance. The skin will be sufficiently thin so that the temperature gradient normal to the skin will be negligible. Therefore, it will be assumed that the thermocouples attached to the back surface actually measure the temperature of the skin at each location.

The analog signals output by the thermocouple array will be digitized by use of either the 160 channel data acquisition system located in Building 222 or the 50 channel data acquisition located in Building 262. The digital data tape output by either of these systems will be compatible with the CAD UNIVAC 1108 digital computer system. The existing EHTS03 (Q566) program will be used to calibrate the experimental data in engineering units and output a data tape for input to the required thin skin transient heating rate model program. See Figure 1 for a diagram of the data flow and test configuration."

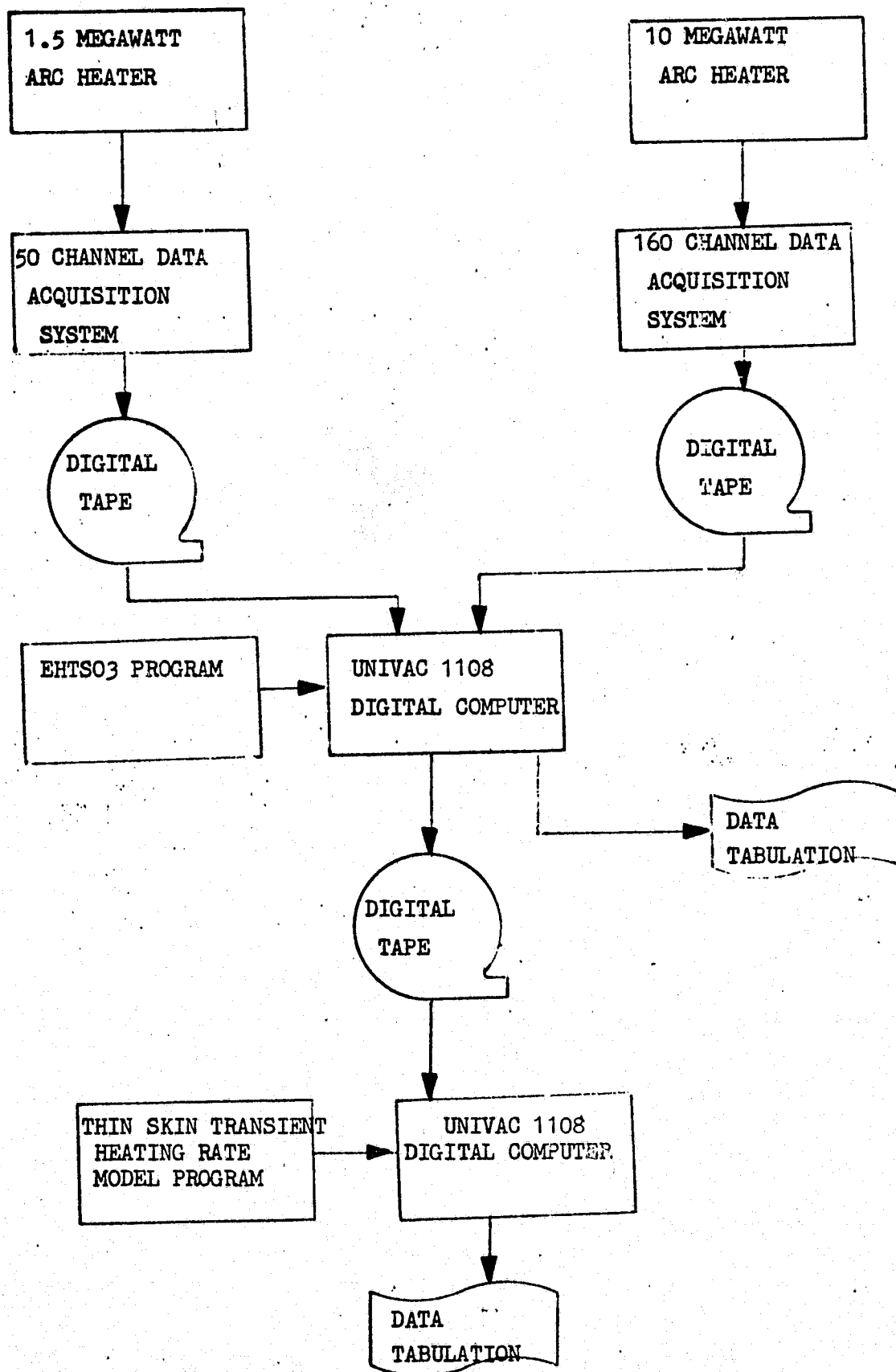


Figure 1
TEST CONFIGURATION

III

DATA PROCESSING REQUIREMENTS

The hardware required to accomplish the data processing task will be the UNIVAC 1108 digital computer. The software required will be the existing EHTS03 (Q566) program and the Thin Skin Transient Heating Rate Model Program specified in Appendix A.

The data processing procedure will consist of the steps listed below:

1. The project engineer will have the data tape and the lead card input for the EHTS03 program delivered to the test data coordinator in Room 228 of Building 12.
2. The data coordinator will issue instructions for computer processing and notify the project engineer when the processing is complete.
3. The project engineer will review the EHTS03 data and provide lead card setups for the thin skin transient heating rate model program.
4. The data coordinator will issue instructions for computer processing and notify the project engineer when the processing is complete.

IV

TECHNICAL REFERENCES

1. Memo: ES5/9-24(9)/249M, Memorandum to: ED/Chief, Computation and Analysis Division; from: ES/Chief, Structures and Mechanics Division; Subject: Requirements for a computer program to calculate heating rates using thin skin models.
2. Program Documentation, Experimental Heat Transfer Data Reduction Package #3 (EHTS03), Program Q566, Project 4556, August 1969.

APPENDIX A
PROGRAMING SPECIFICATION
for
THIN SKIN TRANSIENT HEATING RATE MODEL PROGRAM

I

PURPOSE

The purpose of this program will be to compute the heating rate at each of a number of locations on the surface of thin skin transient heating rate models. Experimental data, calibrated in engineering units, will be obtained from the ABEL tape output by the EHTSO3 computer program. The program output will consist of time history tabulations of computed data with options for input and intermediate computation tabulations.

II

INPUT

The program inputs will be the ABEL time history data tape output by the EHTSO3 program and the lead card inputs necessary to specify computational constants, input data channels, command channels, options, and command event levels. The magnetic input data tape will consist of FORTRAN written data records in a single data file. The first data word in each record will be the time word. The remaining words will be the data channel words ordered by channel number. The tape will be written with 800 bit per inch density and odd parity using the UNIVAC 1108 computer.

The lead card inputs will include, but not be limited to, the following items. The exact card formats will be determined by the programmer.

1. Two cards, each containing at least sixty column alphanumeric entries will be used to identify the data contained in the output tabulation. This input will appear in the title of each page of the tabulation.

2. Coordinate positions for each thermocouple with a maximum array of 50x50 positions. The upper left hand position will be designated $T_{xy} = T_{11}$ as shown by Table 1 in Section III.
3. Input tape data channel number for each thermocouple in T_{xy} array.
4. Physical locations of each row and column. All locations will be determined from the row and column containing $T_{xy} = T_{11}$ in inches.
5. Input tape data channel number for the command channel.
6. Command channel signal level used to start computations. Millivolt level.
7. Command channel signal level used to terminate computations. Millivolt level.
8. Input tape data channel number for the time channel. Normally channel 1.
9. Start computation time.
10. Stop computation time.
11. Coordinate positions of known erroneous thermocouple data.
12. Option to tabulate tape input temperatures.
13. Option to tabulate intermediate computation results.

14. Computational constants:

- a. Mass density (ρ) of the test material in pounds mass per cubic foot. (lbm/ft³)
- b. Specific heat (C_p) of the test material in Btu/lbm °F
- c. Material thickness (d) in inches
- d. Thermal conductivity (K) in Btu/ft sec°F

III

TABLES

The thermocouple instrumentation used to measure the temperatures on the thin skin transient heating model will be arrayed in the rectangular coordinate system shown by Table 1. The maximum size of the array will be 50x50. The minimum array will be 3x1 or 1x3. Only line, rectangular or square arrays will be defined. Other array configurations may be computed if dummy data is input to fill out the array. Even though the thermocouple array will generally be rectangular, the spacing between rows and columns will not normally be the same. Therefore, the distance of each row and column from $T_{1,1}$ will be a separate card input. The array will be computed as for a planar surface regardless of the actual configuration of the model. That is, the last row will not be adjacent to the first row as in the case of a cylindrical surface, etc. Spherical and conical surfaces will not be defined other than as rectangular arrays.

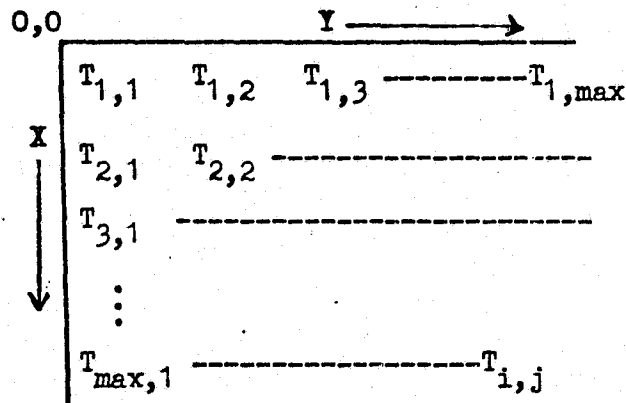


TABLE 1

THERMOCOUPLE ARRAY

COMPUTATIONS

Equation 1 will be the energy balance equation used to describe the heating applied to the model surface at each coordinate (x_i, y_j) for each data time sample (t_k) .

Equation 1:

$$\dot{q}_{ij} = \left(\frac{\rho d C_p}{12} \right) \left(\frac{\partial T_{ij}}{\partial t} \right) + \left(\dot{q}_{ij}^x \right) + \left(\dot{q}_{ij}^y \right)$$

where:

\dot{q}_{ij} : Heating rate to the model surface X_i, Y_j

ρ : Mass density of surface material

d : Material thickness of surface material

C_p : Specific heat of surface material

$\left(\frac{\partial T_{ij}}{\partial t} \right)$: Derivative computed by the use of equation 2

$\left(\dot{q}_{ij}^x \right)$: Derivative computed by the use of equation 4

$\left(\dot{q}_{ij}^y \right)$: Derivative computed by the use of equation 5

Equation 2 will be used to compute the partial derivative of temperature with respect to time for the thermal mass around the thermocouple test point for each data time sample (t_k).

Equation 2:

$$\frac{\partial T_{ij}}{\partial t} = b_k + 2C_k t_k$$

Where:

b_k : Determined by solution of equations 3a, 3b, and 3c

C_k : Determined by solution of equations 3a, 3b and 3c

Equations 3a, 3b and 3c will be solved for b_k and C_k by the use of the Gauss-Jordan or other appropriate method for the solution of simultaneous equations.

$$T_{ij}(t_{k-1}) = a_k + b_k t_{k-1} + C_k (t_{k-1})^2$$

$$T_{ij}(t_k) = a_k + b_k t_k + C_k (t_k)^2$$

$$T_{ij}(t_{k+1}) = a_k + b_k t_{k+1} + C_k (t_{k+1})^2$$

Where:

a_k, b_k, c_k : Coefficients of a second degree polynomial

t_{k-1} : Time of preceeding data sample from ABEL input tape

t_k : Time of current data sample

t_{k+1} : Time of succeeding data sample

Equation 4 will be used to compute the lateral heat loss in the X direction for input to equation 1 for each time sample (t_k).

Equation 4:

$$\dot{q}_{1j}^x = 24 \text{ kd} \left[\left(\frac{1}{X_{i+1} - X_{i-1}} \right) \left(\frac{T_{1j} - T_{i-1,j}}{X_1 - X_{i-1}} + \frac{T_{i+1,j} - T_{1j}}{X_{i+1} - X_1} \right) \right]$$

Where:

k : Thermal conductivity (card input)

d : Material thickness (card input)

$X_{i+1} - X_{i-1}$: Distance between thermocouples located on either side of X_1 thermocouple, etc.

$T_{1j} - T_{i-1,j}$: Input data temperature difference between thermocouples.

Equation 5 will be used in the same manner as equation 4 to determine the lateral heat loss in the Y direction for each data time sample.

Equation 5:

$$\dot{q}_{1j}^y = 24 \text{ kd} \left[\left(\frac{1}{y_{j+1} - y_{j-1}} \right) \left(\frac{T_{1j} - T_{i,j-1}}{y_j - y_{j-1}} + \frac{T_{i,j+1} - T_{1j}}{y_{j+1} - y_j} \right) \right]$$

Equation 1 will be set to zero for the two end points in a test array consisting of a single line of thermocouples. Further, equation 1 will be set to zero for the four corner transducers in a square or rectangular array. That is:

$$2 \leq i \leq I-1,$$

$$2 \leq j \leq J-1$$

where: I and J are defined as the greatest i and j limits, respectively, of the transducer array.

Equation 1 will be computed for the test points in the transducer array that lie on the four sides of 3x2, 2x3 or larger arrays. Either equation 4 or equation 5 will be modified as required to prevent erroneous results due to lack of valid inputs for the transducers located on the sides of the test array. For test points located on the upper side of the test point array, equation 6 will be used instead of equation 4.

Equation 6:

$$\dot{q}_{ij} = 24 \text{ kd} \left(\frac{2}{x_2 - x_1} \right) \left(\frac{T_{2j} - T_{1j}}{x_2 - x_1} \right)$$

For test points located in the lower side of the array, equation 7 will be used in lieu of equation 4.

Equation 7:

$$\dot{q}_{I,j}^x = 24 \text{ kd} \left(\frac{2}{x_I - x_{I-1}} \right) \left(\frac{T_{I,j} - T_{I-1,j}}{x_I - x_{I-1}} \right)$$

Equation 5 will be valid regardless of whether equations 6 or 7 are used for upper and lower limit test points.

For test points located on the left side of the array shown in Table 1, equation 8 will be used in lieu of equation 5.

Equation 8:

$$\dot{q}_{i,1}^y = 24 \text{ kd} \left(\frac{2}{y_2 - y_1} \right) \left(\frac{T_{i,2} - T_{i,1}}{y_2 - y_1} \right)$$

For test points located on the right side of the array, equation 9 will be used in lieu of equation 5.

Equation 9:

$$\dot{q}_{i,J}^y = 24 \text{ kd} \left(\frac{2}{y_J - y_{J-1}} \right) \left(\frac{T_{i,J} - T_{i,J-1}}{y_J - y_{J-1}} \right)$$

Equation 4 will be valid regardless of whether equations 8 or 9 are used for left or right test points. Note that the end points of a linear array and corner points of a rectangular array will not be computed, as previously stated.

Card input will be used to specify which if any, of the input test points have invalid tape data input due to hardware malfunction in the test hardware or the data acquisition system. Computations for the test points on the four sides of the invalid points will be made by using the input temperature from and the distance to the thermocouple on the opposite side of the faulty point. For example, if $T_{2,2}$ were faulty (see Table 1), $\dot{q}_{2,1}$ would be computed using $T_{2,3}$ for the temperature input and $Y_3 - Y_1$ for the distance input to equation 5. Note that the program will be designed to salvage data only for points within the array. A bad point at any edge or corner of the array will be eliminated by deleting that row or column from the program input. Substitution of data from a similar point may also be done by card input. No provision will be made for computing data around specified bad input points that are separated by at least one row or column of good input data.

Computations will be controlled by card input start-stop times or by card input command channel levels. Either one or the other may be used, but not both. Start-stop times will be input in seconds and milliseconds. Command Channel start and stop levels will be input at the same levels used in the ETHS03 program. These levels will be 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90 and 95 millivolts plus or minus 2.5 millivolts.

PROGRAM OUTPUT

The program output will consist of tabulations of the input lead cards, thermocouple array format, computed and input data. No data tape will be output. Each page of the tabulated output will be identified by the card input identification title in addition to any other identification, column headings, etc. The tabulations will include:

1. Tabulation of all input card data.
2. Row by row tabulation of input tape data channels: This tabulation will start with the channel number for $T_{xy} = T_{11}$ and list the input data channels in 10 columns across the page. See Table 1 for a typical format. Channel numbers assigned will be set to zero for those channels specified as erroneous by card input.
3. Row by row tabulation of computed heating rate (\dot{q}_{ij}) for each time history slice. The time of each sample will precede each beginning row of computed data. Time will be output in seconds and milliseconds.
4. Optional row by row tabulation of tape input data temperatures for each time history slice as tabulated in 3, above.
5. Optional row by row tabulation of computed X and Y heat losses (\dot{q}_{ij}^X and \dot{q}_{ij}^Y) as in 3, above.

Note that tabulated data outputs for non-computed end points, corner points and bad data points will set to zero.



HOUSTON AEROSPACE SYSTEMS
16811 EL CAMINO REAL
HOUSTON, TEXAS 77058
TELEPHONE: (AREA CODE 713) 488-0080

LOCKHEED ELECTRONICS COMPANY

In reply refer to:
TDR#2247

October 31, 1969

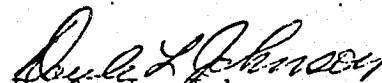
TO: ED5/Chief, Data Processing Branch
FROM: LEC/Manager, Test Data Reduction Department
SUBJECT: Technical Memorandum 11-69-622, October 27, 1969,
Requirements for a Thin Skin Transient Heating
Rate Model Program

Subject Technical Memorandum was received by the Test Data Reduction Department on October 29, 1969.

Responsibility for the requested programming support has been assigned to Mrs. Yvonne Chempinski. Mrs. Chempinski has been working from preliminary requirements documents. The program has been completed on schedule with test output delivered to Doctor Scott. Two minor additions were requested by Doctor Scott and will be completed shortly.

Please direct any additional communications regarding this project to Mrs. Chempinski at HU8-0080, extension 345 or Mr. Len Martin, ext. 336.

Unless otherwise directed, all effort expended on this task will continue to be charged to Project Number 4556.


Doyle L. Johnson

DLJ:JDG:pm
Distribution: J. Fisher/ED57
E. Grice/ED57
J. Randall/C18
Y. Chempinski/B11
L. Martin/B11
D. Garrett/B11

UNITED STATES GOVERNMENT

Computation and Analysis Division
NASA Manned Spacecraft Center
Houston, Texas 77058

Memorandum

TO : LEC/Manager, Test Data Reduction
Department, 672-10

DATE: November 18, 1969

FROM : ED5/Chief, Data Processing Branch

In reply refer to:
11-69-634

SUBJECT: Requirements for modification of the THNSKN (Q614) program

Programing support is required to modify the Thin Skin Transient Heating Rate Model Program. The modifications requested by Dr. C. D. Scott of the Experimental Heat Transfer Section of the Structures and Mechanics Division are listed below:

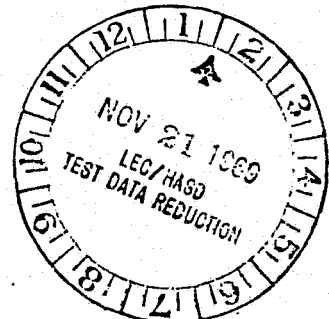
- a. Change the card input format for X and Y coordinates from F 5.1 to F 10.3...
- b. Change the data output print format to F 10.3.
- c. Make the tabulation of tape input data temperatures, X and Y lateral heat losses as standard output rather than optional.
- d. Compute end point and corner point data for the thermocouple array rather than setting this data to zero.

It is understood that Mrs. Yvonne Chempinski has started work on these modifications in response to a verbal request from Dr. Scott. Work on this task should be a continuing charge to project number 4556. For further information, please contact E. O. Grice, extension 5533.


Fred Fulton

cc:
ES56/Dr. C. D. Scott
ED57/J. L. Fisher

ED57:EOGrice(LEC:JMRandal):ddc 11-18-69



8-18





HOUSTON AIRSPACE SYSTEMS
16811 EL CAMINO REAL
HOUSTON, TEXAS 77058
TELEPHONE: (AREA CODE 713) 488-0080

LOCKHEED ELECTRONICS COMPANY

In reply refer to:
TDR#2267

November 25, 1969

TO: ED5/Chief, Data Processing Branch
FROM: LEC/Manager, Test Data Reduction Department
SUBJECT: Technical Memorandum 11-69-634, November 18, 1969
Requirements for Modification of the THNSKN (Q614)
Program

Subject Technical Memorandum was received by the Test Data Reduction Department on November 21, 1969.

Responsibility for maintenance of the THNSKN program has been assigned to Mrs. Yvonne Chempinski. The program modifications specified in the subject Technical Memorandum have been completed, and the modified program has been validated.

Please direct any further communications regarding this task to Mrs. Chempinski, HU8-0080, extension 345.

As directed, all effort expended on this task will continue to be charged to Project Number 4556.


Doyle L. Johnson

DLJ:JDG:pm
Distribution: J. L. Fisher/ED57
E. O. Grice/ED57
J. M. Randal/C18
Y. Chempinski/B11
J. D. Garrett/B11



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS 77058

IN REPLY REFER TO: 11-69-636

24 NOV 1969

TO : LEC/Manager, Test Data Reduction Department 672-10

FROM : ED5/Chief, Data Processing Branch

SUBJECT: Requirements for modification of the THNSKN (Q614) program

Programing support is required to modify the Thin Skin Transient Heating Rate Model Program. Equations 4 and 5 are to be changed to the form shown below:

Equation 4:

$$\dot{q}_{ij}^X = 24kd \left[\left(\frac{1}{X_{i+1} - X_{i-1}} \right) \left(\frac{T_{ij} - T_{i-1,j}}{X_i - X_{i-1}} - \frac{T_{i+1,j} - T_{ij}}{X_{i+1} - X_i} \right) \right]$$

Equation 5:

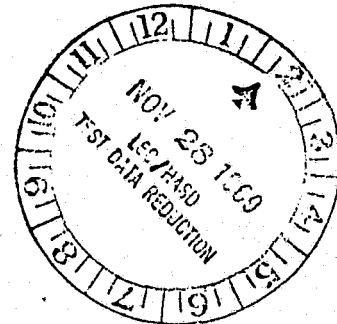
$$\dot{q}_{ij}^X = 24kd \left[\left(\frac{1}{Y_{j+1} - Y_{j-1}} \right) \left(\frac{T_{ij} - T_{i,j-1}}{Y_j - Y_{j-1}} - \frac{T_{i,j+1} - T_{ij}}{Y_{j+1} - Y_j} \right) \right]$$

Mrs. Yvonne Chempinski has started work on these changes in response to a verbal request from Dr. Scott. Work on this task should be a continuing charge to project number 4556. For further information, please contact E. O. Grice, extension 5533.


Fred Fulton

cc:
ES56:Dr. C. D. Scott

ED57/EOGrice(LEC:JMRandal):bc 11-20-69





HOUSTON AEROSPACE SYSTEMS
16811 EL CAMINO REAL
HOUSTON, TEXAS 77058
TELEPHONE: (AREA CODE 713) 488-0080

LOCKHEED ELECTRONICS COMPANY

In reply refer to:
TDR#2272

December 1, 1969

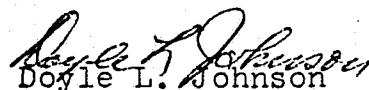
TO: ED5/Chief, Data Processing Branch
FROM: LEC/Manager, Test Data Reduction Department
SUBJECT: Technical Memorandum 11-69-636, November 24, 1969
Requirements for Modification of the THNSKN Program
(Q614)

Subject Technical Memorandum was received by the Test Data Reduction Department on November 28, 1969.

Programming support for the subject program has been assigned to Mrs. Yvonne Chempinski of the Data Acquisition Systems programming group. Mrs. Chempinski has completed the requested program modifications having worked from a verbal request from Doctor Carl Scott.

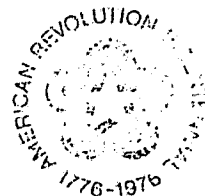
Please direct any additional communications regarding this project to Mrs. Chempinski, HU8-0080, extension 345, or to Mr. Len Martin, the Engineering Applications Programming team leader, at extension 336.

As directed, all work expended on this task will continue to be charged to Project Number 4556.


Doyle L. Johnson

DLJ:JDG:pm
Distribution: J. L. Fisher/ED57
E. O. Grice/ED57
J. M. Randal/C18
Y. Chempinski/B11
L. Martin/B11
J. D. Garrett/B11

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS 77058



REPLY TO
ATTN OF: ES35

December 23, 1974

Lockheed Electronics Co. Inc.
Attn: Mr. James Brose
Mail Stop C-30
16811 El Camino Real
Houston, TX 77058

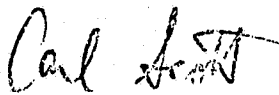
Dear Mr. Brose:

A software change request was issued by Mr. E. J. Jung and ~~me~~^{me} on October 23, 1974, to incorporate changes into the thin skin heating rate data reduction computer program (THNSKN). Equation (2) of that document should be

$$q = \frac{1}{24} \frac{\rho C_p d^{N-1}}{t_N - t_1} \frac{N-1}{N-2} (T_{ij}^N - T_{ij}^{N-1} - T_{ij}^1 - T_{ij}^2)$$

The expressions in equations (5) and (6) should be carrying a negative sign.

Please incorporate these corrections into the program.


C. D. Scott

LOCKHEED ELECTRONICS COMPANY, INC
AEROSPACE SYSTEMS DIVISION

16811 EL CAMINO REAL

HOUSTON, TEXAS 77058

TELEPHONE (AREA CODE 713) 481 0280

In reply refer to:
#121-8315-199
J.O. #83-157

December 31, 1974

TO: FD5/Chief, Data Processing Branch
FROM: LEC/Manager, Data Processing Systems Department
SUBJECT: Transmittal of EXEC VIII Version of the THNSKN Program

Transmitted herewith is the EXEC VIII version of THNSKN program for the Structures and Mechanics System. This version replaces the EXEC II version.

Results from the validation runs, after being checked for correctness with the use of LEC generated test data, were submitted to the customer, Dr. Carl Scott. Upon his acceptance, the Software Change Request was signed by the SIC and NASA Project Leader. The Software Change Request form is attached giving the descriptive reason for program modification.

W. N. Fitzpatrick
W. N. Fitzpatrick

WNF:JEM:jlb
Attachments

cc: H. Stephenson/FD53
D. L. McCormick/FD52
C. Scott/ES3
E. J. Jung/ES3
C. E. Hutchinson/C30
C. F. Iven/C11
[REDACTED]
J. Brose/C30
J. E. McFarland/C30
J. O. File

LOCKHEED ELECTRONICS COMPANY, INC
AEROSPACE SYSTEMS DIVISION

16811 EL CAMINO REAL

HOUSTON, TEXAS 77058

TELEPHONE (AREA CODE 713) 488 0080

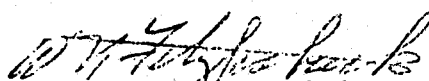
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W. N. Fitzpatrick

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Attachments

cc: H. Stephenson/FD53
D. L. McCormick/FD52
C. Scott/ES3
E. J. Jung/ES3
C. E. Hutchinson/C30
C. F. Iven/C11

J. Brose/C30
J. E. McFarland/C30
J. O. File

SOFTWARE CHANGE REQUEST

Date Oct. 23, 1974

Requester/ E.J. Jung, Jr.
Organization E.J. Jung/C. Scott/JSC-ES

Need Date Dec. 31, 1974

To Be Completed By Responsible Organization

Job Order 83-15 SCR No. 83-15-30

Program Name THNSKN

Program No. Q614

Project No. 4300

Target Date 12/31/74

REASON FOR CHANGE:

To improve the accuracy and automation of the computer program THNSKN used to calculate heat fluxes from temperature time histories measured on thin skin heat transfer models tested in JSC arc tunnel facilities.

CHANGE DESCRIPTION (attach extra sheet if necessary):

See the attached description.

TO BE COMPLETED BY RESPONSIBLE ORGANIZATION

ESTIMATED RESOURCES:

Man-Hours 120

Computer Hours 2.0

APPROVALS BY:

C. A. Shultz Task Manager

W. J. Scott Technical Monitor

W. J. Scott Branch Chief

11/11/74
Date

11-12-74
Date

11/14/74
Date

Date

TRANSMITTAL TO PRODUCTION:

Submitted by:

E. J. Jung, Jr. Programmer Date 12/30/74

Validation approved by:

E. J. Jung, Jr. System Integration Coordinator Date 12/30/74

E. J. Jung, Jr. Project Leader Date 12/30/74

E. J. Jung, Jr. Project Leader Date 12/30/74

- ☒ Operating system
- ☒ New program decks have been submitted to production
- ☒ Transmittal tape replaces current system CUR, PUR
- ☒ Overlay production CUR/PUR with transmittal CUR/F
- ☒ Symbolic elements are contained in file number
- ☒ Relocatable elements are contained in file number
- ☒ No changes are required in execution deck setup
- ☒ Changes in run instructions are attached
- ☒ Transmitted program tape number

ACCEPTANCE BY PRODUCTION:

Date test 8-24
run completed

Project Leader Date

SOFTWARE CHANGE REQUEST

Date Oct. 23, 1974

Requester/ E.J. Jung/C. Scott/JSC-ES

Need Date Dec. 31, 1974

To Be Completed By Responsible Organization
Job Order 83-15 SCR No. 83-15-30

Program Name THNSKN

Program No. Q614

Project No. 4300

Target Date 12/31/74

REASON FOR CHANGE:

To improve the accuracy and automation of the computer program THNSKN used to calculate heat fluxes from temperature time histories measured on thin skin heat transfer models tested in JSC arc tunnel facilities.

CHANGE DESCRIPTION (attach extra sheet if necessary):

See the attached description.

TO BE COMPLETED BY RESPONSIBLE ORGANIZATION

ESTIMATED RESOURCES:

Man-Hours 120

Computer Hours 2.0

APPROVALS BY:

<u>[Signature]</u>	<u>4/11/74</u>
Task Manager	Date
<u>[Signature]</u>	<u>11-12-74</u>
Technical Monitor	Date
<u>[Signature]</u>	<u>11/14/74</u>
Branch Chief	Date

TRANSMITTAL TO PRODUCTION:

Submitted by: [Signature]
Programmer Date

Validation approved by: [Signature]
System Integration Coordinator Date

[Signature] Date
NASA, Project Leader

- ☒ Operating system
- ☒ New program decks have been submitted to production
- ☒ Transmittal tape replaces current system CUR, PUR
- ☒ Overlay production CUR/PUR with transmittal CUR/F
- ☒ Symbolic elements are contained in file number
- ☒ Relocatable elements are contained in file number
- ☒ No changes are required in execution deck setup
- ☒ Changes in run instructions are attached
- ☒ Transmitted program tape number

ACCEPTANCE BY PRODUCTION:

Date test 8-24
run completed

Project Leader Date

THIN SKIN PROGRAM MODIFICATION

Code modifications are required to improve the accuracy and automation of the computer program THINSKN used to calculate heat fluxes from temperature time histories measured on thin skin heat transfer models tested in the JSC arc tunnel facilities. The modification described here will also allow one discontinuity in the skin thickness (in one direction only) and uses finite difference expressions which are approximately second order accurate (except at end points) in both the space and time derivatives of the heat conduction equation.

The following modifications are required:

- 1) At present the computer program calculates heat fluxes only during one time period. Modify the program so that the number of time periods that heat fluxes are calculated during a run from may be specified in the input.
- 2) Compute the average heat fluxes for each time period and print the average for each location.
- 3) Remove the restriction that if bad thermocouples are at end points of rows or columns of thermocouples, the computation is ~~absorbed~~ absorbed. Use the next good thermocouple ^{as} on the end point.
- 4) Compute the conduction correction at end points (last good thermocouple) using the same conduction correction as at points adjacent to the end point. e.g., $\bar{q}_{i1}^y = \bar{q}_{i2}^y$
- 5) Allowance for discontinuity in skin thickness — In the input two skin thicknesses, d_1 and d_2 , are to be specified along with

the position y_d of the junction between the two thicknesses

$d = d_1$ for $y < y_d$ and $d = d_2$ for $y > y_d$

Use the appropriate thickness d for each location.

- 6) Compute the mean heat flux for each time interval using the formula

$$\bar{q}_{ij} = \bar{q}_{ij} + \bar{q}_{ij}^x + \bar{q}_{ij}^y \quad (1)$$

where:

$$\bar{q}_{ij} = \frac{1/6 \rho c_p d}{t_{i+1} - t_i} \frac{N}{N-2} (T_{ij}^N + T_{ij}^{N-1} - T_{ij}^1 - T_{ij}^2) \quad (2)$$

$$\bar{q}_{ij}^x = \frac{24 K d}{x_{i+1,j} - x_{i-1,j}} \left(\frac{\bar{T}_{ij} - \bar{T}_{i-1,j}}{x_i - x_{i-1}} - \frac{\bar{T}_{i+1,j} - \bar{T}_{ij}}{x_{i+1} - x_i} \right) \quad (3)$$

$$\bar{q}_{ij}^y = \frac{24 K d}{y_{i,j+1} - y_{i,j-1}} \left(\frac{\bar{T}_{ij} - \bar{T}_{i,j-1}}{y_j - y_{j-1}} - \frac{\bar{T}_{i,j+1} - \bar{T}_{ij}}{y_{j+1} - y_j} \right) \quad (4)$$

To compute \bar{q}_{ij}^y at thermocouple locations adjacent to the skin thickness jump (y_d) use the following formulas for $y_k < y_d < y_{k+1}$ instead of \bar{q}_{ij}^y (4).

$$\bar{q}_{ik}^y = \frac{24 K d_1}{y_{k+1} - y_{k-1}} \left(\frac{\bar{T}_{ik+1} - \bar{T}_{ik}}{y_k - y_{k-1}} + \frac{d_2 (\bar{T}_{ik+1} - \bar{T}_{ik})}{(y_d - y_k) d_2 + (y_{k+1} - y_d) d_1} \right) \quad (5)$$

$$\bar{q}_{i,k+1}^y = \frac{24 K d_2}{y_{k+2} - y_k} \left(\frac{d_1 (\bar{T}_{ik+1} - \bar{T}_{ik})}{(y_d - y_k) d_2 + (y_{k+1} - y_d) d_1} + \frac{\bar{T}_{ik+2} - \bar{T}_{ik+1}}{y_{k+2} - y_{k+1}} \right) \quad (6)$$

The bars over the T's denote time average of the temperatures throughout a given interval. The superscripts on the T's in the first term denote the first, second, last, and next to last temperatures in the time interval. The number of samples in a time interval is N. The first time in the interval is t_1 and the last is t_N . The latter two terms in equations (3) and (4) are the lateral heat loss terms as used previously except now they are averages over the time interval. This procedure will replace the one currently used in the code.

- 7) Output - Print the start and stop times for each time interval.

Print out the number of times N in each interval, the times t_n and temperatures T_n^i at each time. No longer print the heat flux terms at each time since these are no longer calculated.

Print each of the terms in equation (1): \bar{q}_{ij} , \bar{q}_{ij}^x , \bar{q}_{ij}^y

and the net heat flux \bar{q}_{ij} . Continue to compute and print the linear least squares heat flux in the revised program. Finally, print the mean of \bar{q}_{ij} averaged over the number of time intervals specified in the input.

- 8) Amend program documentation to reflect these and any previous changes.

ATTACHMENT 9

DIAGNOSTIC MESSAGES

DIAGNOSTIC MESSAGES

FEWER POINTS THAN REQUESTED

This message occurs at the end of a time slice when the number of points accumulated for least squares heat flux computations is less than the requested (NTME). This is not necessarily abnormal.

PARITY ERROR RECORD DELETED

An input record has been skipped because of parity errors.

END OF FILE ENCOUNTERED ON UNIT 8. PROCESSING OF ACCUMULATED DATA WILL BE ATTEMPTED.

Normally, stop times or stop event levels should be chosen so that the end-of-file is never encountered. If at least three scans of data have been accumulated, processing will be done.

TOO FEW POINTS AVAILABLE FOR CURVE FIT

Fewer than three data points have been stored so no least squares heat flux computations can be done.

***ERROR - NX OR NY IS BAD

Either one or both of NX and NY are too large or too small. Currently, the maximum size for either is 50. Either NX or NY must have a minimum value of 3.

Examples:	<u>NX</u>	<u>NY</u>	
	1	3	Valid
	3	1	Valid
	2	2	Invalid
	1	50	Valid
	51	51	Invalid

***ERROR - NTME IS LARGER THAN NN

The requested number of points to be used for least squares heat flow computations exceeds array dimensions (NN). Currently NN is 50.

***ERROR - TOO MANY CHANNELS

The number of channels specified for the input tape is too large for the array dimensions. Currently, the maximum number of channels which can be processed is 260.